ARMY ORDNANCE

VOL. XXVII, No. 147 NOVEMBER-DECEMBER, 1944

Outline of Victory
Gen. Dwight D. Eisenhower

Bombs Away!
Brig. Gen. R. C. Coupland

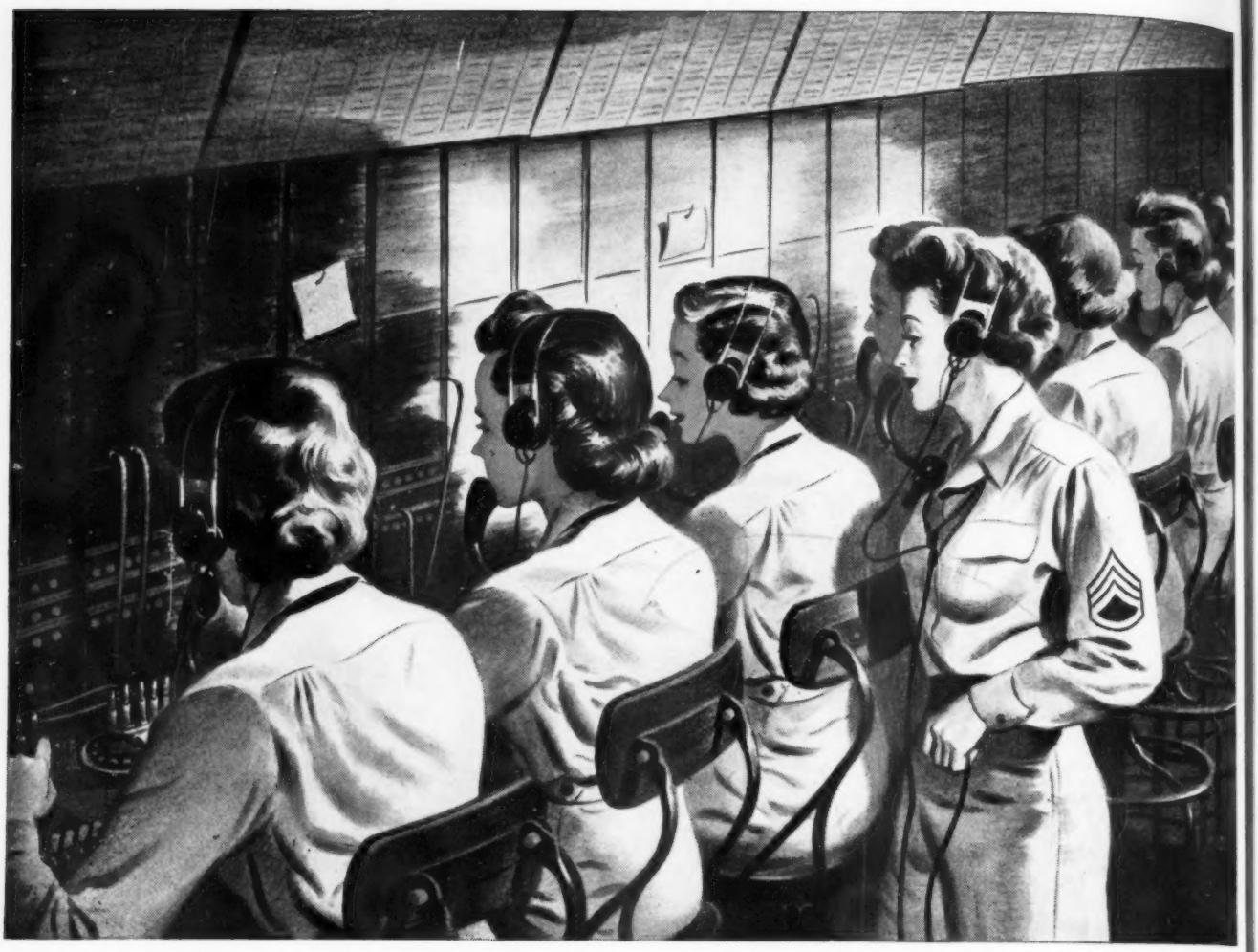
Heavy Artillery Ammunition
Brig. Gen. R. E. Hardy

The Age of Chivalry
Maj. Gen. J. F. C. Fuller

Metallurgical Warfare
Lieut. Col. G. L. Cox

Ordnance Research
An Editorial

A REVIEW OF INDUSTRIAL PREPAREDNESS FOR NATIONAL DEFENSE
PUBLISHED BY THE ARMY ORDNANCE ASSOCIATION, WASHINGTON, D. C.



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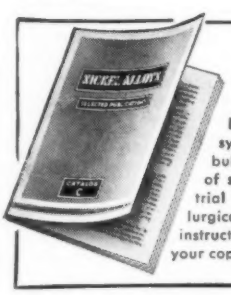

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ARMY ORDNANCE

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Founded 1920

For Victory through Armament Research, Production, and Supply

Volume XXVII **NOVEMBER-DECEMBER, 1944** **No. 147**

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(Publication date: November 1, 1944)

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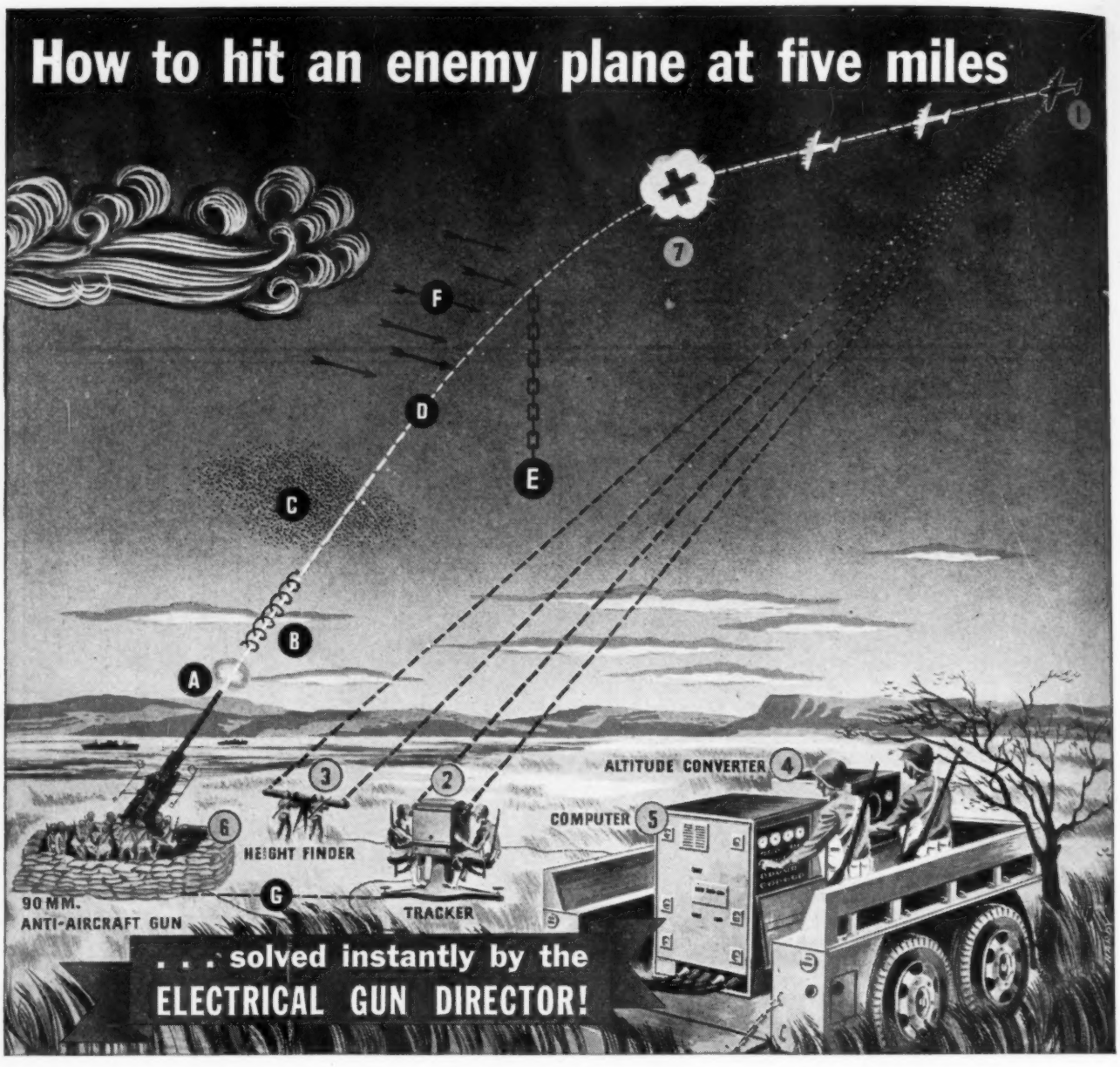
How to hit an enemy plane at five miles



The Problem

An enemy bomber is sighted 5 miles away, 3 miles high, flying fast. He's within range of your 90 mm. anti-aircraft battery. A shell will take perhaps 20 seconds to reach him, but meanwhile he'll have flown nearly 2 miles. How could you possibly tell where to aim *to hit such a speeding target?*

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Developed by Bell Telephone Laboratories men working with Army Ordnance experts, and made by Western Electric, the *electrical* Gun Director has made our anti-aircraft fire more accurate than ever. It is one of many electrical weapons produced by the makers of Bell Telephones.

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THE ARMY ORDNANCE ASSOCIATION

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THE Army Ordnance Association, a national society of over 30,000 American citizens, was founded in 1919, "pledged to industrial preparedness for war as our Nation's strongest guaranty of peace." The society was incorporated under the laws of the District of Columbia in 1928. Its entire energies are now dedicated to victory for the armed forces of the United States. For the duration of the war it is "pledged to victory—complete, absolute, final."

The Association has endeavored during the past twenty-five years to keep alive an interest in and knowledge of the design, production, and maintenance of military armament. This it has done through periods of public lassitude and times of great national emergency. Until 1940 there was no peacetime armament industry in the United States for the production of ordnance. Now all American industry is geared for victorious war production.

The principal objective of the society is an active membership of American citizens to assist in the design, development, procurement, production, maintenance, and supply functions of the Ordnance Department of the United States Army. When peace returns, this body of informed citizens will again continue to be a bulwark of knowledge, experience, and ability upon whom the Armed Forces of the United States can rely for technical and scientific assistance and for industrial preparedness.

The Association is devoted solely to the national defense; it has no commercial interests, no political alliances, and no religious affiliations. It is not operated for profit: its income is expended in furthering its aims. Its elected officers and directors serve without remuneration. Membership, to which American male citizens are eligible, is $4.00 a year or $10.00 for three years. (Application on request.) There are twenty-five local chapters of the Association throughout the United States.

All members are eligible to attend national and local meetings of the Association. In addition they receive the following publications without additional cost:

ARMY ORDNANCE, the journal of the Association, published solely for the purpose of disseminating information on the progress of our armament developments so that American science and industry may at all times know their responsibilities to the common defense;

FIREPOWER, the Ordnanceman's magazine, issued bimonthly, which contains current articles of special interest to enlisted men, noncommissioned officers, and junior commissioned officers on subjects relating to the performance of ordnance in battle;

ARMY ORDNANCE BULLETIN, a monthly Washington newsletter containing items of current interest on armament developments and progress;

ARMY ORDNANCE REPORTS, issued from time to time, bring to members authentic analyses of special Ordnance subjects in the fields of industrial operations, matériel performance, and general Ordnance information.

Additional objectives of the Association as set forth in its Constitution are:

To promote mutual understanding and to effect coöperation with American scientists, inventors, engineers, and manufacturers in civil life and the Regular and Reserve officers of the Ordnance Department;

To commemorate the services rendered by the industry of the Nation and by the officers and civilian employees of the Ordnance Department in the wars in which the United States has been engaged.

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(*Continued from preceding page*)

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Beachhead on Biak

Coast Guard photo

ARMY ORDNANCE

Volume XXVII NOVEMBER-DECEMBER, 1944 No. 147

Outline of Victory

A Balance Sheet of Our Successes in Northern France

Gen. Dwight D. Eisenhower

THE following report was made by Gen. Dwight D. Eisenhower, Supreme Commander, AEF, on the results of operations in northern France between D-day, June 6th, and August 25th:

The equivalent of five Panzer divisions have been destroyed and a further six severely mauled, including one Panzer Grenadier division. The equivalent of twenty infantry divisions have been eliminated and a further twelve very badly cut up and have suffered severe losses. . .

One thousand three hundred enemy tanks and over twenty thousand motor transports have been captured or destroyed. About 500 assault guns and 1,500 field and heavier artillery guns have been captured or destroyed. In addition, the enemy has suffered very heavy losses in coast-artillery equipment. The German Seventh Army and the newly formed Fifth Panzer Army have been decisively defeated, and into this defeat has been drawn the bulk of the fighting strength of the First and Fifteenth Armies. . .

In the air, the *Luftwaffe* has taken a fearful beating. Since June 6th, 2,378 German aircraft have been destroyed in the air and 1,167 on the ground. In addition, 270 aircraft were probably destroyed and 1,028 aircraft damaged in the air.

At sea, the enemy has been unable, in spite of his former boasting, to interfere seriously with the invasion forces. Enemy attacks on convoys have been driven off on very many occasions, and losses to allied shipping have been small. Of the enemy's naval losses, some 300 vessels of all classes have been sunk or heavily damaged by allied action. In addition, a number of enemy merchant ships have been sunk, and the Germans themselves have been forced to scuttle, in their harbors, large numbers of all types of shipping, both naval and mercantile.

A large proportion of the enemy's effort has been devoted to attack by mine laying. The sustained work of mine sweepers has resulted, within three months, in a "mine-bag" off the French beaches which totals one-tenth of all mines swept in five years in all theaters of war. . .

Many factors are woven into the warp and woof of this great victory. Among these a few are listed below, with no attempt to give their order of importance.

One was meticulous care in planning and preparation, supported resolutely in all important aspects by the Combined Chiefs of Staff.

Another was the fact that we achieved some degree of surprise involving place, timing, and strength of the attack. The excellence and sufficiency of amphibious equipment, with measures for dealing with beach defenses and obstacles, was also important.

The brilliant preparatory work of the Air Forces, a belief in the effectiveness of which was the very cornerstone of original invasion conception, began months ago and reached its highest intensity at the very moment of landing. It is my conviction that except for this aërial preparation, including as a specific mission a prolonged campaign against the transportation systems of northwest Europe, the venture could not have logically been undertaken. The air support of the Ground Forces has been most effective throughout the campaign. The supply and maintenance services have performed miracles.

But the greatest factor of all has been the fighting qualities of the soldiers, sailors, and airmen of the United Nations. Their valor, stamina, and devotion to duty have been beyond praise. They will continue to be.

ALL American units were shipped to France with full equipment. Nevertheless, during the first 70 days of the operation, United States Ground Forces required more than 900 tanks to replace battle casualties. In that same period we replaced other losses in the following amounts: 2,400 automatic rifles, 1,750 quarter-ton trucks, 1,500 mortars, and 83,000 miles of field wire.

At our present strength, and on a basis of strict rationing, we are using 150,000 tons of ammunition per month. This includes 40,000,000 rounds of caliber .30 ammunition, 800,000 rounds of mortar, and 900,000 rounds of 105-mm. ammunition.

These are merely a few examples and do not take into account expenditures in the British Army, in which many items, especially tanks, are manufactured in the United States. All French divisions are equipped exclusively with American models.

In supporting this operation, the Air Force has lost 3,000 airplanes and has consumed in replacement parts and spares the equivalent of 225 more. It has dropped more than 55,000 tons of bombs and used 44,000,000 gallons of aviation gasoline.

In the important item of heavy-duty trucks our needs increase every day. Each advance means more trucks for assuring supply. Yet this campaign must expand both in strength and in speed of movement in order to bring about a rapid victory and take advantage of the opportunities we have already gained. We must have trucks of all kinds and sizes. As a special item I must include tires, particularly heavy-duty tires for big trucks and airplanes. Our need in tires is acute.

I must urge that you keep flowing across the Atlantic at maximum rate all those things, including spare parts, that a modern army and air force require in battle.

General Eisenhower is Supreme Commander of the Allied Expeditionary Forces. This report was made on August 31, 1944.

Heavy Artillery Ammunition

Brig. Gen. R. E. Hardy

The invasion of Europe created a tremendous demand for heavy shells, even while the need for other types of ammunition was increasing. A revision of the entire powder and explosives setup was necessary—a challenge which American industry met with its customary ingenuity.

WHILE the Chief of Ordnance has always advocated greater firepower, the nature of the operations during the early part of this war did not require any considerable amount of heavy artillery. Small-arms ammunition and bombs were consumed in very large quantities, but it was not until the action in Italy that the rates of expenditure of heavy artillery ammunition rose to uncontemplated heights.

Consequently, production of heavy shells progressed at a more or less even, though low, rate through most of 1943 and early 1944. In April and May, demands from the field made it imperative that production of all types of shells for 4.5-inch guns, 155-mm. guns and howitzers, 8-inch guns and howitzers, and 240-mm. howitzers be increased as rapidly as possible. A directive of May 19th, signed by Lieut. Gen. B. B. Somervell, established the maximum monthly rates of production to be attained. New rates, expressed as percentages of those in effect on April 1st, were as follows: 4.5-inch gun, 440; 155-mm. gun, 262; 155-mm. howitzer, 470; 8-inch gun, 350; 8-inch howitzer, 980; 240-mm. howitzer, 655.

The first step taken by the Ordnance Ammunition Division was to have all existing facilities increase their rates to the maximum limit and to add new machine tools to eliminate bottlenecks in the lines. This action, while immediate, did not produce any appreciable result. Even a limited number of machine tools took time to build, and additional labor was very hard to get. In fact, shortage of labor in some instances made it necessary to start new facilities rather than expand old ones which could not get even enough labor to man existing lines.

The next step was to set up a separate heavy-artillery section in the Ammunition Division with Col. S. R. Stribling as chief. This section with two officers, two civilian production engineers, and two clerks, employed George O. Desautels, president of the George O. Desautels Company, as consultant on forging equipment, and Robert R. Stephens, president of the Robert R. Stephens Machinery Company, as consultant on shell-machining equipment.

All Ordnance districts took immediate steps to recommend suitable plants and contractors for the production of the various types of shells. The Navy and the War Production Board were very coöperative in suggesting idle plants or plants in which cutbacks were contemplated. In some cases

General Hardy is chief of the Ammunition Division, Ordnance Industrial Service.

cutbacks or cancellations were speeded up in order to allow heavy shell production to be initiated at once. The War Manpower Commission gave advice as to where expansions could be manned.

As a result of these combined recommendations, a plan for the complete shell program was drawn up in about ten days. This plan was analyzed by representatives of the Ammunition Division; Headquarters, Army Service Forces; War Manpower Commission; and the facilities, steel, and fuel sections of the War Production Board. A portion of the plan was approved informally by all concerned at the first meeting. This permitted the preparation of site letters, their immediate signature by the Under Secretary of War, and the placing of orders for equipment. Considerably more analysis and negotiation were necessary to set up the balance of the plan, and the final facilities set up were agreed upon only after weeks of effort with all agencies involved.

However, this did not delay the program, as the early approval of part of the plan permitted loading the sources of machine tools. Machine-tool orders for the whole program were placed long before the initial orders had been completed. The continued study of suitable locations did result in placing the bulk of the program in existing plants in locations where the War Manpower Commission indicated labor can be secured. Of course, some new plants were necessary, but prompt action by the Corps of Engineers put construction way ahead of delivery of machine tools.

THE heavy-shell program, however, is only one part of the heavy-ammunition program. Shell facilities were set up first, but capacity for rotating bands, fuzes, lifting plugs, and cartridge storage cases had to be expanded. Bag-loading plants had to be revamped to be able to produce the thousands of large propelling charges in addition to their former small and medium charges.

Demands for other types of ammunition have not decreased, and rates of production of some, such as bombs, are also increasing. Hence, the addition of the demands for increased heavy artillery ammunition made a revision of the whole powder and explosives situation necessary. An uncompleted smokeless-powder plant is being finished. Two idle TNT plants are being reopened. Capacity for black powder must be increased, as must capacity for toluene, ammonia, nitric acid, and sulphuric acid. Tank cars must be converted from other uses as purchased. Government-owned loading plants are being expanded, and new lines are being built at others to accommodate the demand. This expansion requires additional housing secured through coöperation with the National Housing Administration and additional transportation which must be arranged with the Office of Defense Transportation. The recruitment of approximately 50,000 additional workers is a fair-sized job in itself even with this program on the top priority list with first referrals being granted by the United States Employment Service. Special recruiting drives are being aided by Army shows of the caravan type set up and operated by the various service commands.

While it is normal to think of heavy-artillery ammunition as large shells, it must be remembered that such shells must be placed on the enemy with destructive effect. To accomplish this, many components and materials are required, all of which must be produced in balance as to quantity and time and the results proof-fired prior to delivery to troops. The General Staff directed that the peak rates desired would be reached as soon as possible and not later than fourteen months from the date of the directive. As outlined above, the program requires the full coöperation of many Government agencies as well as hundreds of contractors. Thanks to their combined efforts, forecasts are being met and the prospects are excellent that peaks will be reached well in advance of the limit set by the General Staff.

Altorfer Brothers, East Peoria, Ill.; War Supplies Limited, Ottawa, Canada; Pullman-Standard Car Manufacturing Company, Butler, Pa.; National Cast Iron Pipe Company, Birmingham, Ala.; Willys-Overland Motors, Inc., Toledo, Ohio; W. F. and John Barnes, Rockford, Ill.; Giddings & Lewis Machine Tool Company, Fond du Lac, Wis.; Minneapolis-Moline Power Implement Company, Minneapolis, Minn.; Atlas Imperial Diesel Engine Company, Mattoon, Ill.; General Motors Corporation, Oldsmobile Division, Lansing, Mich.; Omaha Steel Works, Omaha, Nebr.; Mueller Company, Decatur, Ill.; Goslin-Birmingham Manufacturing Company, Birmingham, Ala.; Gullett Gin Company, Amite, La.; Rockwood Alabama Stone Company, Russellville, Ala.; Central Foundries, Holt, Ala.; J. I. Case Company, Racine, Wis.; General Motors Corporation, Pontiac Motors Division, Pontiac, Mich.; General Motors Corporation, Fisher Body Division, Grand Rapids, Mich.; Rheem Manufacturing Company, Danville and Williamsport, Pa.; United Engineering and Foundry Company, New Castle, Pa.; U. S. Hoffman Machine Company, Syracuse, N. Y.; Kaiser Company, Inc., Shell Division, Fontana, Calif., and Denver, Colo.; Reed Roller Bit Company, Houston, Tex.; Hughes Tool Company, Houston, Tex.; Long Reach Machine Works, Houston, Tex.; Florence Stove Company, Kankakee, Ill.; U. S. Pipe and Foundry, Addyston, Ohio; Jones & Laughlin Steel Corporation, McKeesport, Pa.; Petroleum Heat and Power Company, Stamford, Conn.; Batavia Metal Products Company, Batavia, Ill.; Struthers-Wells, Titusville, Pa.; American Type Founders, Elizabeth, N. J.; Kelly-Springfield Tire Company, Cumberland, Md.; Oil Well Supply Company, Oil City, Pa.; National Steel Corporation, Weirton Steel Company, Weirton, W. Va.; Harrisburg Steel Company, Harrisburg, Pa.; American Car and Foundry Company, Buffalo, N. Y.; Babcock Printing Press Company, New London, Conn.; Treadwell Construction Company, Midland, Pa.; Watertown Arsenal, Watertown, Mass.; E. G. Budd Manufacturing Company, Bustleton, Pa.; Kentucky Shell Manufacturing Company, Newport, Ky.; National Can Company, Minneapolis, Minn.

PRINCIPAL PRIME CONTRACTORS FOR THE HEAVY ARTILLERY AMMUNITION PROGRAM

While it is impossible to list all the contractors furnishing equipment, materials, etc., the principal prime contractors for this tremendous program are listed on this page. The program entailed new facilities of approximately $200,000,000 split 50 per cent for metal parts and 50 per cent for additional explosives and loading capacity.

EDITOR'S NOTE.—Col. T. C. Gerber, Field Director of Ammunition Plants, writing on "Ammunition Production" in the March-April 1943 issue of ARMY ORDNANCE (Vol. XXIV, No. 137), stated: "Of the new Ordnance facilities some manufacture propellent powder for the Army and Navy, including the various types of cannon and small-arms powder, diphenylamine, TNT, DNT, oleum, sellite, tetryl, toluol, anhydrous ammonia, ammonium nitrate, picric acid, ammonium picrate, lead azide, formaldehyde, hexamine, barium nitrate, and acetic acid; some load artillery primers, fuzes, boosters, detonators, bombs, and shells."

Air Forces

Bombs Away!

Ordnance with the Air Forces

Brig. Gen. R. C. Coupland

THE most significant figure on our August bomb-expenditure report was that representing the bomb tonnage dropped by B-29's, the mighty Superfortresses of Maj. Gen. Curtis LeMay's Twentieth Bomber Command, on five raids over Japan and Japanese-held territory. This tonnage seemed unimportant when compared with the European theater total of 65,875 tons for the same month by British- and Normandy-based bombers. But the relatively small quantity should properly be regarded as a token of the thousands of tons of high-explosive and incendiary bombs to come—a presage of what Japanese militarists may expect in the near future.

It is certain that our Superfortresses will increase in numbers. As we get more bases close to Japan, bombers can be employed by the hundreds and thousands, instead of by scores. Also certain is the fact that bomb tonnages dropped on Japan will mount steadily in the months ahead. Pioneer American air raids on Japan therefore represent for the Japanese military clique a really terrifying prospect. As in the case of Hitler's *Festung Europa,* the upward-spiraling curve of bomb expenditures in the Far East will result in the steady, progressive, and inexorable destruction of Japanese industrial facilities, aircraft factories, public utilities, ports and harbors, oil and ammunition dumps, transportation and communication systems—in short, the very heart and sinews of the sprawling Japanese war machine.

Bombs are our business. Small antipersonnel bomb clusters and mammoth blockbusters. Bombs for the liberation of the Philippines. Bombs for Ansham and Yawata and Yokohama. Bombs for our British, Russian, and other allies. Bombs are the chief concern of the Air Ordnance Office, though perhaps in a less romantic manner than that of the war correspondents who describe the spectacular deep-penetration raids of our air armadas. For our part, bombs expended mean bombs to be procured, and procurement involves all the complex problems of rapid mass production in hundreds of factories in all parts of the country. Air Ordnance serves as the liaison between the Air Forces, which employs bombs as avenging flails on numerous strategic and tactical mis-

General Coupland is Air Ordnance Officer, U. S. Army.

sions, and the Ordnance-Industry team, which manufactures them. At the disposal of the Air Ordnance Office are the research and development facilities of the AAF Technical Service Command, the AAF Proving Ground Command, and the vast scientific and industrial resources of the Ordnance Department itself.

Aviation Ordnance, in short, is that part of the mission of the Ordnance Department which applies to the Army Air Forces. While Army Ordnance is the procuring agency for ordnance items of exclusive interest to the Air Forces, requirements and monthly production schedules are set up and monitored by the Air Ordnance Office, and this office handles in whole, or in large part, all the various functions of Ordnance for the Air Forces.

The Air Ordnance Office in Headquarters, Army Air Forces, is set up to parallel as far as possible the organization of the Chief of Ordnance in Army Service Forces Headquarters. Thus there is a Field Service Branch which performs as nearly as possible the functions of Field Service in the Office, Chief of Ordnance, except that practically all supply matters, exclusive of combat ammunition, have been delegated to the Air Technical Service Command. The Air Ordnance Office also has a large Technical Developments Branch which monitors the development of ordnance matériel and coördinates the requirements of the Air Forces for new weapons with the Research and Development Service of the Office, Chief of Ordnance. The relations of Air Ordnance with the Industrial Service are obtained through our Procurement Supervision Branch which furnishes to the War Plans and Requirements Division of the Office, Chief of Ordnance, the bases for computation of ordnance requirements for the Air Forces.

THE first Ordnance service in the Air Forces was established by Maj. Gen. Russell L. Maxwell almost ten years ago. At that time General Maxwell, then a lieutenant colonel, was Ordnance officer of the GHQ Air Force. Among the Regular Army Ordnance officers assigned for Aviation Ordnance duty were Cols. Edison A. Lynn, Arthur B. Custis, Edward P. Mechling, James S. Neary, Philip Schwartz, Wiley T. Moore, and Ralph H. Bassett.

Colonel Lynn, now chief of the Cleveland Ordnance District, was the Aviation Ordnance officer in the original attack in North Africa and also went through the Sicilian campaign and most of the Italian campaign before returning to this country for duty in the Office, Chief of Ordnance. Colonel Custis was the Ordnance officer for the Air Force in Hawaii and is now the Ordnance officer for the Fourth Air Force on the West Coast. Colonel Mechling, who is now in G-4 with General Maxwell, served in England, Africa, and Italy, either as the Ordnance officer of an air force or as the A-4. Colonel Neary was stationed in the Philippines at the outbreak of the war and took part in the heroic defense of the islands. Colonel Schwartz is now the Ordnance officer in the United States Strategic Air Force. Colonel Moore is the Ordnance officer for Maj. Gen. Claire L. Chennault, while Colonel Bassett, formerly the Ordnance officer of the Second Air Force, is now on a special mission for Gen. H. H. Arnold. During the time these officers were operating with the GHQ Air Force, the present Air Ordnance Officer represented the Chief of Ordnance in the Office of the Chief of the Air Corps.

From the few platoons of the 10th Ordnance Company, Aviation Ordnance has expanded until we are currently providing approximately 5,000 officers and over 60,000 enlisted men for Ordnance service in the Army Air Forces. Problems of Aviation Ordnance at the beginning of the war were in general those of the Army itself—we were short of everything. However, Aviation Ordnance, primarily because of the prompt response of the Chief of Ordnance to our urgent calls for matériel, was ready for all-out air operations before planes could be manufactured and pilots and crews trained for the effort that is now being made on such a gigantic scale.

ONE of the greatest problems in the procurement and supply of bombs for the Air Forces is that the airplane must be considered a multicaliber artillery piece. The wide range of bombs, varying from the 20-pound fragmentation bomb to the 4,000-pound demolition blockbuster, makes it possible to use the airplane as though it were of every caliber from .30 to 240 mm. This necessitates very careful planning in the pattern of bomb procurement. Furthermore, the constant changing of objectives makes it necessary to have on hand in overseas bases sufficient bomb stocks to provide for continuing missions with any specific type of bomb. As a consequence, the over-all tonnage procurement at times appeared excessive in view of expenditures, but so carefully were loading factors worked out that, not so long ago, the parallel between bomb production and airplane expenditures was almost perfect.

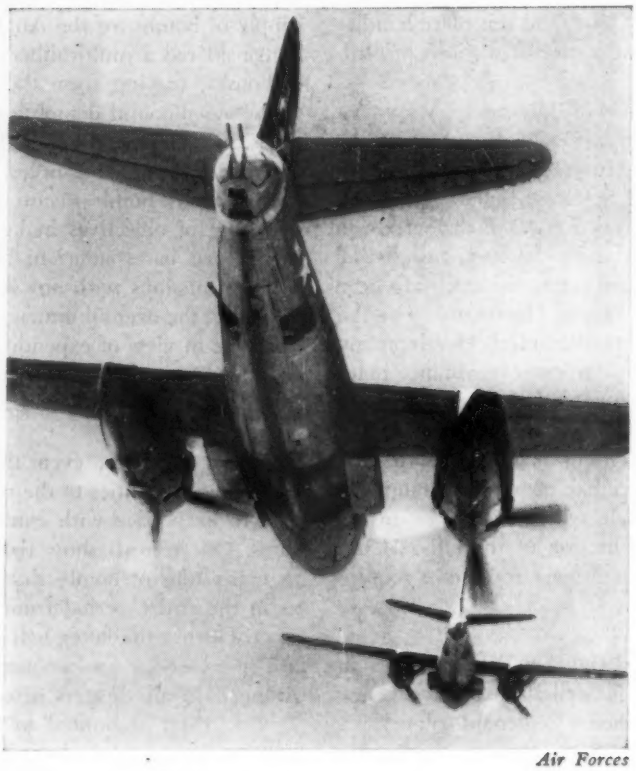
Today, however, even though we are utilizing all resources and facilities to the maximum extent, we are scarcely able to keep pace with extraordinarily high bomb expenditures. Our records show that the Air Forces dropped twice as many tons of bombs during the first six months of 1944 as in the entire period from Pearl Harbor to December 31, 1943. During the latter half of 1944 our bomb requirements are in excess of 700,000 tons. The total tonnage of bombs dropped in all theaters of operation from Pearl Harbor to July 1, 1944, amounted to 677,012 tons, of which 472,054 tons were dropped during the period from January 1st through June 30th.

Our logistical requirements for aërial bombs were greatly revised during the past summer. We met less fighter opposition than we originally expected, and our attacks on the German aircraft industry were highly successful. Our losses were lighter and, owing to improved sighting devices, we were able to bomb successfully under a wider range of weather conditions and hence were able to go on more missions. In the European theater of operations, for example, following the intensification of air war on all Nazi industrial targets, there was a 500 per cent increase in the tonnage of bombs dropped between January and June, with an overall of 405,212 tons for the 6-month period. Of this total, 243,402 tons were dropped by the Eighth and Ninth Air Forces operating from England and the beachhead in Normandy.

As an indication of the intensification of bombing activity preceding the liberation of France, American aircraft based in Great Britain dropped 14,105 tons of bombs on German installations in January. This tonnage steadily increased until June, D-month, when 85,648 tons of bombs, or more than 5 times the January total, were showered on German industrial and military targets. In addition, the Twelfth and Fifteenth Air Forces in the Mediterranean theater steadily intensified the air-borne punishment inflicted on the enemy until, by the end of D-month, they had cascaded a total of 161,810 tons of bombs on German installations.

Bomb expenditures for the South, Southwest, and Central Pacific have been negligible by comparison with the European theater. For the first seven months of 1944, a total of 66,568 tons were dropped in all 3 areas. It should be noted, however, that the majority of targets in these areas were and are tactical and that far fewer bombs were required to destroy shipping, troop, and supply concentrations than were needed to eliminate the industrial sections of German cities. Mention should also be made of the mobility of air power as contrasted with the immobility of stock piles. To stock the Pacific area with sufficient bombs to carry on any type of operation, there have to be thousands of tons available at hundreds of small air bases where they may not be used for months, depending on tactical requirements.

Even in the Pacific area, bomb requirements, although relatively small, skyrocketed in 1944. A breakdown shows that in the Southwest Pacific, 22,410 tons of bombs were dropped in 1943 and 39,882 tons during the first seven months of 1944—a 200 per cent increase. In the South Pacific, 7,644 tons were expended in 1943 and 17,397 tons from January through July 1944—an increase of 300 per cent. In the Central Pacific, where a unique situation existed, only 1,309 tons were dropped in 1943, as contrasted with a requirement for 9,289 tons for 7 months of 1944—an increase of 1,200 per cent. The reason for these large increases was that the rapid advance of our forces, supported by long-range bombers, gave us a number of new air bases on our island steppingstones. Many of these air bases had to have Air Forces ammunition dumps, and to keep these dumps supplied many more bombs were required, even though they were not expended immediately. The speed of a bomber may be 300 miles an hour, but it takes a lot more time to ship aircraft bombs and to establish adequate ammunition supply centers.



Air Forces

MARTIN B-26 MARAUDERS ABOUT TO DROP THEIR BOMBS OVER FLORENCE, ITALY

Bomb expenditures in the China-Burma-India theater have remained small because of transportation difficulties, the types of targets, and the temporary concentration of much of our air power on the European continent. However, as the war enters its final and perhaps most difficult phase in the Far East, we may expect bomb requirements to mount very rapidly.

The War Production Board revealed early in September that American aircraft plants turned out about 1,500 four-engined bombers a month in June, July, and August, and that the gigantic total of at least 15,000 heavy bombers had been made during the preceding 12 months. WPB also announced that a total of 8,000 planes of all types were made in July, 7,939 in August, and that modified September schedules called for 7,934 planes. Over-all aircraft production will taper off on X-day, when Germany is vanquished, but there will be no cuts in the over-all production of aircraft bombs. The reason for this unusual situation is that the unprecedented aërial activity prior to, during, and subsequent to the liberation of France and the Low Countries resulted in such an unprecedented expenditure of bombs of all types that strategic reserves were seriously depleted—depleted to the extent that many months of production will be necessary to raise our stock piles within the continental limits of the United States to a normal wartime level.

In view of the current recession in the over-all production of war matériel, it should be remembered that none of the items used by Air Ordnance were found on the War Production Board's long supply list of unobligated stocks as of August 18, 1944. At the same time, the changing nature of the war in Europe, from long-range bombing of industrial targets to short-range bombing of enemy concentrations in the vicinity of the front lines, necessitated a revision of bomb requirements. There is less need for heavy general-purpose bombs and more need for relatively light clusters of fragmentation and other antipersonnel bombs. The almost complete absence of the *Luftwaffe* over occupied Europe, except for relatively infrequent guerrilla raids, made it possible for our medium bombers and bomb-carrying fighters to strike almost at will at an infinite variety of targets.

The actual tonnage of bombs dropped by aircraft operating from England and the coast of France during the month of June amounted to approximately half as many tons as were dropped in all theaters during the entire year of 1943. Heavy overseas shipments of bombs began in March and were gradually increased to the point where the tonnage that cleared our ports for the European theater reached a total of 117,000 in May and 162,000 in June.

These vast overseas shipments depleted stock piles in this country, particularly with reference to 250-pound, 500-pound, and 1,000-pound general-purpose bombs, by as much as 50 per cent. This depletion necessitated the reopening of production of the smaller-size bombs.

The cessation of hostilities in Europe will have no immediate effect on the production of high-explosive bombs because it will again be necessary to build up strategic reserves while at the same time continuing offensive air operations against Japan and Japanese-occupied China. Furthermore, the wide dispersal of targets and bases in the Pacific area will make necessary stock piles as much as two and three times for the same number of airplanes as we are now able to put into the air over Europe. There is no likelihood of a cutback in bomb production in the near future.

British official photograph

British Armored Cars

Design and Armament of Vehicles for Reconnaissance and Attack

Marcus W. Bourdon

Britain's fast and formidable "tanks on wheels" have been blasting the Nazis from El Alamein to Normandy. The six principal types described here include such features as double-end steering, ability to climb a 50 per cent grade, and armament as heavy as the 6-pounder (57-mm.) antitank gun.

ARMORED cars, some of them veritable "tanks on wheels," have been used with marked success by the British armies on all fighting fronts from El Alamein to France. They fall into two categories: (1) the armored but lightly armed reconnaissance cars and (2) the more heavily armed and armored vehicles used for either scouting or attack.

There are six types in all, designed and produced by five motor manufacturing companies: Morris, Humber, Karrier, Daimler, and A.E.C. (Associated Equipment Company). Morris and Humber in peacetime build private passenger cars; Karrier makes light and medium-weight trucks; Daimler produces private passenger cars and buses, while A.E.C. builds heavy trucks and for many years past has manufactured the vast majority of London's buses.

With one exception, the Morris reconnaissance car, all have 4-wheel drive, for their sphere of action is by no means confined to paved roads; primarily, indeed, they are designed for cross-country travel, and it may be said that their ability to operate at high speeds on good roads is more or less incidental, every basic feature and many of the details of construction being designed for "rough going" on soft surfaces ranging from desert sand to dirt tracks and deep mud. The majority will often operate across country as readily as a tank or other tracked vehicle. All have pneumatic tires, the Dunlop R.F. type—"R.F." standing for "run flat," which means that even though the tires become deflated through penetration by enemy gunfire or other cause the vehicle can continue to run safely, without risk of loss of control or immediate irreparable damage to the tire.

At this point it may be said that, comparing the more heavily armed and armored examples of these cars with the tank, the former have advantages that frequently compensate for their somewhat inferior capabilities in negotiating soft ground. For instance, they can cover a far greater mileage without servicing and overhaul; they are capable of

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maintaining high speeds for much longer distances—without stop, if need be; they need no transporter to take them from one battlefield to another far away or when following a rapidly retreating enemy force; and their tires have an incomparably greater mileage life than the tracks of a tank and do not require frequent attention or renewal if damaged. The armored car, admittedly, cannot carry such heavy armament as the heavier type of tank, but, as shown hereafter, the 6-pounder (57-mm.) gun is not beyond its capabilities, and with this armament it is better equipped for attack or defense than were many tanks until not so long ago.

In all British vehicles of this kind, except the Humber reconnaissance car, the engine is at the rear end of the chassis. This departure from normal practice in cars and trucks enables the driver to be seated much lower and farther forward than if he had the engine in front of him and units of the transmission below his feet. This in turn permits both he and his armor-plate "cabin" to be located well below the field of fire from the guns within the turret, while the latter can be comparatively low in over-all height. The vehicle as a whole, therefore, forms a smaller target and has a lower center of gravity that makes it more stable on uneven ground. A further advantage of the rear engine is that it enables the wheelbase of the vehicle to be shortened, thus enhancing maneuverability by reducing the radius of the turning circle for a given angle of front (steering) wheel deflection.

Fig. 1. Morris 3½-ton Reconnaissance Car
Armament: One Bren gun and one antitank rifle.

There is marked diversity in frame design. In the Morris, for instance, the superstructure and the frame are combined, resulting in what, in passenger-car parlance, is a "chassisless" construction; the main components—power plant, transmission units, spring suspension, steering gear, etc.—are all attached to the lower part of the superstructure. In the Humber and the Karrier, a more or less conventional frame is used, with the superstructure attached to it at four points through the medium of flexible mountings. Thus any distortion of the frame on uneven ground is intercepted before it can take effect upon the hull.

Daimler uses yet another frame construction, a flat base of armor plate with upturned edges and stiffening webs, making a flat-bottomed "tray" which serves well to protect the transmission and other components above it from damage in rocky and hummocky country. At mid-length there is a projection or "blister" at each side containing and protecting the fuel tanks. Frame and hull are bolted together at many points and form in service a single unit of great rigidity.

Turning now to details of the various vehicles, the Morris (Fig. 1) is one of the three intended primarily for scouting with infantry and is one of the lowest in weight—3¼ long tons (7,250 pounds). It is distinctive in being the only one with a 4-cylinder engine which develops 72 brake horsepower at 3,000 revolutions per minute and exhibits departures from normal practice in having (1) an oil-cooling radiator for the almost conventional lubricating system, (2) a "closed" water-cooling system, in which the radiator is sealed but has a steam pressure blow-off valve, and (3) thermostatically controlled shutters covering the lower part of the radiator.

The transmission system consists of the usual friction clutch, a 4-speed gearbox of the usual sliding type, a transfer gearbox (the purpose of which is referred to later), and a universally jointed propeller shaft to the spiral bevel final drive and differential.

The engine is located in front of the rear axle, though its fan shaft projects behind the axle to bring the fan close to the radiator, which forms the rearmost component. What is normally the rear of the engine is here the front end (as with all the other rear engines of these armored cars) with the unit-constructed flywheel and clutch casing and the 4-speed gearbox extending forward and carrying at its front end the transfer case. The latter transmits torque through a train of gears to the propeller shaft running back alongside the engine to the final drive in the rear axle only, as this is a 2-wheel-drive vehicle. Apart from the final-drive casing being offset from the center to the left-hand side to provide clearance for the engine, the rear axle is of orthodox design.

The transfer case, with its train of gears, enables a range of eight speeds to be obtained from the 4-speed gearbox; that is, a "high four" and a "low four." The usual gearshift lever is supplemented by a second one by which the change is made from the normal or high series to the emergency or low series when the need for negotiating particularly heavy going becomes apparent.

Spring suspension consists of conventional half-elliptic springs at the rear and independent springing at the front, where coil springs are used with hydraulic shock absorbers and a transverse torsion bar to check "rolling" on rough ground. Here it may be said that fifty miles an hour on hard roads is within the capacity of the vehicle. Pedal-operated brakes are Lockheed hydraulic with a tandem master cylinder, while the hand lever takes effect through mechanical linkage upon the rear brakes only. With a wheelbase of 98 inches, the over-all length of the Morris armored car is 13 feet 3 inches; the wheel track is 66 inches at the front (3 inches less at the rear), and from ground level to the top of the turret the height is 7 feet 4 inches.

Like the remainder of the superstructure, the turret is

built up of armor plate, welded throughout. It houses armament consisting of a Bren gun and an antitank rifle. Entry is gained by a "contortionate" door at the side or by a hatch with a sliding cover in the "deck" by the side of the turret. A crew of three is carried—commander, gunner, and driver. Driving vision is provided by a shallow slot with bulletproof glass. Above this, inside, is a head-protection pad at forehead level to prevent contact with the armor plate when the vehicle passes over exceptjonally rough ground.

DESIGNED like the Morris to accommodate a crew of three, the Humber light armored car (Fig. 2) is distinctive among British vehicles of this type in being the only one with the engine in front of the driver. It weighs 3½ long tons (approximately 8,000 pounds), has 4-wheel drive, 8 speeds gained from a 4-speed gearbox by means of a transfer case giving a normal and a low range of 4 ratios, independent springing at the front only, and 2 propeller shafts from the transfer case to the front and rear axles respectively.

FIG. 2. THE HUMBER 4-TON RECONNAISSANCE CAR
Armament: One Bren gun and one antitank rifle.

The superstructure, of armor plate welded throughout, includes a full-circle rotating turret. Armament consists of a Bren gun on the turret and a Boys antitank rifle projecting through a slot in the armor-plate panel in front of a member of the crew seated alongside the driver. With 6 cylinders, the engine develops 87 brake horsepower at 3,300 revolutions per minute and, appropriately modified, is of the same general design and dimensions as the engine of a series of prewar Humber passenger cars.

As far back as 1938, the Daimler Motor Company, anticipating developments that led to the outbreak of war twelve months later, decided upon its own initiative to prepare designs and build prototypes of two kinds of armored vehicles, the "Scout" for reconnaissance work with infantry and a more heavily armed and armored vehicle for attack and for coöperation with tank units. Within six months the prototypes of both machines had been completed and were under test. During the tests, various modifications suggested themselves or were suggested by the military authorities, and at the outbreak of war all was ready for production on a large scale.

Both types embody certain features associated for many years prior to the war with Daimler passenger cars and buses. First of these is the "fluid flywheel" (hydraulic torque transmitter in place of the usual friction clutch between engine and gearbox). This is used, as in the case of the cars and buses, in combination with the Daimler version of the Wilson planetary (epicyclic) type preselective gearbox. The latter, it may be recalled, enables gear changing to be effected by preselection of a higher or a lower gear ratio by means of a finger-and -thumb lever under the steering wheel, followed, when the change of gear is actually required, by the mere depression and release of the gear-changing pedal.

THE Daimler "Scout," as the lighter of the two types is termed by the makers, has a high-speed, high-efficiency, overhead-valve engine of somewhat smaller piston displacement but of much the same power (70 b.h.p.) as the 4-cylinder Morris, which it resembles also in its fully laden weight, 7,250 pounds. Dry sump lubrication is used, with advantage in securing increased ground clearance for the engine, in permitting an exterior oil-cooling radiator to be provided, and in enabling a large quantity of oil to be carried in and circulated from a separate tank. A dual oil pump is fitted with separate pressure and scavenging sections, as usual with a dry-sump system.

After the drive from the rear engine has passed through the fluid flywheel and the preselective gearbox—a 5-speed unit—it is carried by way of a central transfer case and differential to four propeller shafts, close to the frame sides, leading to a bevel gear casing adjacent to each wheel. A point of interest is the position of the differential gear: it is located centrally between the two pairs of transfer gears serving respectively the two right-hand and the two left-hand propeller shafts. In this position it ensures that wheel spin, and consequent loss of traction, cannot occur unless both wheels on the same side spin simultaneously.

The object of using four propeller shafts, one to each wheel, is twofold. It keeps them out of the way of the driver's floor and avoids the need for central or near-central final-drive casings limiting spring deflection. Actually, the four final-drive casings are bolted to the frame close alongside the wheels, which are driven by short universally jointed cardan shafts running from the crown bevels to the center of the hubs.

The reversing gear is not, as usual, within the multispeed gearbox, but is a separate unit operating through the transfer gears. All forward ratios, therefore, are available for driving backward, and if required (and if the driver is sufficiently competent!) the vehicle can be driven as rapidly backward as forward; *i.e.*, at 50 miles an hour. Gradients of fifty per cent (one foot rise in two feet) are within the capabilities of the vehicle even on soft ground, while the weight distribution and the low center of gravity are such as to permit it, when fully loaded, to be tilted to either side as much as sixty degrees without overturning.

Coil springs are used for the independent springing of front and rear wheels and the amplitude of the suspension permits any wheel to be raised as much as sixteen inches above the ground on which the others rest without tilting

the vehicle as a whole. The wheelbase is notably short, being only seventy-eight inches with a 58-inch wheel track. The armor-plate superstructure is designed to present, as far as possible, a glancing surface to projectiles. The armament is intended for use against infantry only and consists of nothing heavier than a 9.72-mm. Bren gun with an antiaircraft mounting, submachine guns, and rifles.

LIKE the Daimler armored scout car, the heavy type (Fig. 4), weighing approximately 7 long tons (about 16,000 pounds), is designed throughout for its intended purpose; that is to say, it is not a heavy truck modified to carry an armored body, and the same may be said of all the other British armored cars.

FIG. 3. THE KARRIER 8-TON ARMORED CAR

Armament: One antiaircraft machine gun, one 7.92-mm. Besa gun, and one 15-mm. Besa gun (now a 37-mm.).

The 6-cylinder engine at the rear, with the flywheel end at the front, develops 100 brake horsepower at 3,600 revolutions per minute and, with various modifications, is reminiscent of prewar Daimler practice with its inclined overhead valves, antiknock combustion chamber design, counterweighted 4-bearing crankshaft, and torsional vibration damper. But to secure increased ground clearance and other benefits previously mentioned in the above references to the "Scout," dry-sump lubrication is used with circulation through an exterior oil cooler between the scavenging pump and the supply tank. Twin nonspillable carburetors draw air through an oil-bath type of air cleaner.

Transmission as far as the hubs is on the same lines as that of the "Scout"; *i.e.*, through a fluid flywheel, 5-speed preselective gearbox, and a transfer case with the differential between the gears from which the four propeller shafts convey torque to spiral bevel gearing constituting the final drive adjacent to each wheel. At this point a distinctive feature should be noted, for within each hub is epicyclic or planetary gearing giving an additional reduction of 3½ to 1 in gear ratio and enabling an 80 to 1 over-all reduction to be provided for the lowest gear.

This hub reduction gear has several advantages. In the first place it avoids conveying heavy torque through large reduction bevel gears and axle drive shafts and enables the dimensions and weight of these units to be considerably reduced without sacrifice of requisite strength. Another advantage lies in the smaller dimensions of the final-drive (bevel gear) casings, gaining more clearance for parts of the steering, brakes, etc., below them and for parts of the superstructure above. This in turn makes possible an increase of amplitude in the all-wheel independent suspension system. For the latter, dual (side-by-side) coil springs are used, with linkage embodying the so-called "wishbone" system of coupling the wheels to the chassis, locating them and coping with driving torque.

The most notable innovation of the heavy Daimler is undoubtedly the duplicated steering control. The car is exceptionally low at the front, with vision through bulletproof glass in a slot screened by an armored visor, and has a steering wheel on a universally jointed steering column with the usual rake. But in the bevel gear casing at the bottom of the column are two pairs of bevel gears, one pair conveying motion to the usual steering gearbox and the other pair coupled to a jointed shaft that runs back along the floor to bevel gears and a vertical column carrying at the top another steering wheel on a short horizontal shaft. This second steering wheel is within the turret and it enables the commander to steer the vehicle in reverse at any speed he may desire up to the maximum of which the vehicle is capable in a forward direction. The advantage of this facility in an emergency is obvious, as when the commander finds himself ambushed and has neither time nor space to turn around; he can take over from the driver on the instant and drive back away from the danger area.

The commander's steering wheel operates in the normal manner: turning it clockwise for instance, steers the vehicle to the right when it is moving backward. Adjacent to this wheel are a hand-operated throttle, hand-brake lever, and ignition switch. But starting and gear changing must be effected by the regular driver, and although this calls for coöperation between him and the commander when the latter steers, the fluid flywheel and the "self-changing" (preselective) gears make this coöperation comparatively simple when experience has been gained.

The brakes of this heavier Daimler are of quite a new type, but have given full proof of their reliability and efficiency. Instead of the usual brake drum with expanding shoes applying to the interior, there is attached to each wheel hub a flat rotating disk faced on both sides with friction fabric. When the brake pedal is depressed the disk is gripped between two nonrotating clamping or pressure plates by the action of hydraulically operated plungers—or by mechanically operated cams when the hand lever is used. When one of the clamping plates first makes contact with the rotating disk it is free to move slightly, rotationally, with the disk; this movement causes a ball and cam servo device to come into effect and supplement to a marked extent the effort applied by the driver to the brake pedal. The driver effort needed, therefore, to apply the brakes to full effect is reduced by something like seventy per cent.

Within the squat revolving turret, capable of being rotated 360 degrees, are mounted coaxially a high-velocity 2-pounder quick-firing gun and a 7.92-mm. Besa machine gun. In addition, there is a Bren gun on an antiaircraft

mounting. In accordance with general practice in British armored cars, the heavy Daimler has a short wheelbase—102 inches—but the wheel track is remarkably wide, being no less than 78 inches, or approximately the same as that of the largest type of bus with a wheelbase of twice the length or thereabouts.

MADE by one of the many motor-manufacturing companies controlled by Rootes Combine, the Karrier armored car (Fig. 3) represents a combination of Humber design and Karrier production. With a wheelbase of 102 inches and a front-wheel track of 76 inches (72 inches at the rear) it weighs approximately 7 long tons (16,000 pounds) when fully laden. The heavily armored hull carries a full-circle rotating turret on a ball-bearing mounting operated by the gunner by means of a single-speed traversing gear with a control conveniently located at his side. All seats, except that of the driver, are suspended from the turret and therefore rotate with it.

Armament consisted orginally of an antiaircraft machine gun and two Besa guns of 15-mm. and 7.92-mm. caliber respectively; but in a later version the 15-mm. gun has been displaced by one of 37 mm. This alteration has necessitated a reduction in the number of men carried in the turret from three to two—the commander and the gunner, one or the other of whom now undertakes the duties of the displaced radio operator.

The driver, seated well forward, as permitted by the rear engine, has a small window of bullet-proof glass protected by an armored visor; the window can be opened to increase the range of view when fighting is not actually in progress. Well-padded observation flaps opening from the top of the turret enable the commander and gunner to obtain full vision in all directions when the vehicle is not in action. When the flaps are closed, the commander has a Vickers adjustable periscope available. Access to the interior is by small hinged panels, one on each side of the hull. Interior equipment includes a radio transmitter and receiver and an intercommunication telephone between commander and driver. The hull and turret are formed of nickel-chrome-molybdenum alloy plate, with the unit flexibly attached to the chassis (of pressed-steel construction, braced by five cross members) at four points.

Developing 90 brake horsepower at 3,400 revolutions per minute, the 6-cylinder engine is mounted at the rear, with only the radiator behind it. It is prevented from exceeding 3,430 r.p.m. by a dustproof carburetor combined with an automatic governor. The 4-bearing crankshaft is counterweighted. Lubrication is of the conventional pressure type, with a sump below the crankcase and a floating oil intake. An oil cooler is fitted, a somewhat unusual feature associated with this being a hand-operated by-pass valve by which the driver can cut out the cooler while the engine is warming up after a cold start and the oil has still to attain its best working temperature.

Transmission consists of the usual single-plate clutch, a 4-speed gearbox coupled to a 2-speed transfer case providing eight speeds in all (normal four and low four) and two offset propeller shafts, one to each axle, front and rear. When conditions permit the rear wheels only to serve effectively for traction, as on paved roads, the front-wheel drive can be disconnected. The maximum speed on the normal top gear is forty-six m.p.h. at the governed engine speed; on bottom gear of the low series a fifty per cent gradient can be climbed, even on soft ground.

Brakes on all wheels are conventional pedal-operated 16-inch Lockheed hydraulic, but the hand lever operates through mechanical linkage on the rear brakes only. Suspension is by ordinary half-elliptic springs fore and aft, though to permit extensive articulation of the axles without stressing or straining the spring leaves, the spring ends are secured to the chassis by universally jointed shackles.

FIG. 4. THE DAIMLER 8-TON ARMORED CAR

Armament: One 2-pounder gun and one 7.92-mm. Besa machine gun in the turret and one Bren gun on antiaircraft mount.

UP to the moment of writing, very little information has been released by the military authorities about the heaviest and most formidable of British armored cars, the A.E.C. (See illustration on p. 447.) Designed by the Associated Equipment Company, makers of heavy trucks and buses, and produced at several plants in England under A.E.C. supervision, it is the only British armored car to be fitted with a Diesel (compression-ignition) oil engine.

The engine used in the armored car (located at the rear and driving through all 4 wheels) develops 153 brake horsepower at 2,000 revolutions per minute and gives the vehicle a maximum speed of 42 miles an hour on hard roads and 18 miles an hour across country—the latter, presumably, by means of the top gear of a series of low ratios gained from a transfer case.

Giving it the "punch" of a tank, the armament consists of a 6-pounder (57-mm.) antitank gun in an electrically operated turret with full-circle rotation, a 7.92-mm. Besa machine gun mounted coaxially with the 6-pounder, and a light antiaircraft machine gun on top of the turret. The armor plate of the hull and turret is 1¼ inches thick at the front and 1 inch thick elsewhere. The fully laden weight, including crew, ammunition, and radio equipment, is over 12½ long tons (approximately 28,000 pounds). The crew of four consists of the commander, driver, gun layer, and loader, the latter serving also as radio operator when required.

Ordnance Roll of Honor

THE following men have received the Legion of Merit for service as outlined in the accompanying citations:

BRIG. GEN. ELBERT L. FORD, Falls Church, Va.—(*Oak Leaf Cluster*) "For exceptionally meritorious conduct in the performance of outstanding services from August 1942 to February 1944. As Ordnance chief from the inception of Allied Force Headquarters he successfully planned and coördinated all ordnance problems in the preparation for the TORCH operation. Later serving as chief of staff, North African theater of operations, General Ford, by his activities in the formation of the communications zone, was instrumental in solving unprecedented theater problems of over-all supply, communication, and administration of ports. His ability, self-denial, and habitual perseverance in the performance of arduous tasks were incentives to the creation of a smoothly operating staff."

Brig. Gen. E. L. Ford

MAJ. CHARLES E. NORTON, Evanston, Ill.—"For exceptionally meritorious conduct in the performance of outstanding services in the North African theater of operations from August 1, 1943, to January 1, 1944."

Sgt. Sam S. Thomas

CAPT. HENRY J. EGAL (then 1st Lieut.), Brooklyn, N. Y.—"For exceptionally meritorious conduct in the performance of outstanding services in the North African theater of operations from September 10, 1943, to April 5, 1944."

1ST LIEUT. EDWIN L. LOWE, Schuylkill, Pa.—"For exceptionally meritorious conduct in the performance of outstanding services from March 1 to September 15, 1941, in connection with off-shore defenses."

Sgt. John R. Davis

2ND LIEUT. EDWIN D. THOMPSON, Los Angeles, Calif.—"From June 28 to October 5, 1943, in the North African theater of operations, he met the recurring shortage of automotive parts by designing and manufacturing in quantity fourteen different parts and twenty-three different labor- and time-saving tools as well as developing a practical and efficient table of limits and tolerances to accommodate oversize and undersize automotive parts. . . . He more than doubled weekly average engine production."

TECH. 4TH GRADE SAM S. THOMAS, Sanford, Fla.—"For service from November 1, 1943, to March 1, 1944. He displayed an exceptionally high degree of initiative, efficiency, ingenuity, skill, and devotion to duty in the design, construction, and operation of a device for straightening the frames of two motor vehicles concurrently. This device is responsible for the repair of a number of vehicles which otherwise might have had to be salvaged and for saving many vehicular deadline days and man-hours."

Lieut. W. D. Garland

TECH. SGT. HAROLD F. McMILLAN, Wollaston, Mass.—"For exceptionally meritorious conduct in the performance of outstanding services in the North African theater of operations from March 22 to December 12, 1943."

TECH. 4TH GRADE JOHN R. DAVIS, Stamford, Nebr.—"For exceptionally meritorious conduct in the performance of outstanding services in the European theater of operations from March 22, 1944, to March 23, 1944."

M. Sgt. J. I. Dotterer

THE following men have been awarded the Bronze Star Medal for service as outlined in the accompanying citations:

MAJ. JAMES R. BRIGHT, Saint Davids, Pa.—"For meritorious achievement in connection with military operations against the enemy at Guadalcanal . . ."

TECH. 5TH GRADE EARL V. EHRHARDT, Altadena, Calif.—"For meritorious achievement in connection with military operations . . . in the Central Pacific area."

2ND LIEUT. WALTER D. GARLAND, Fort Worth, Tex.—"As bomb-disposal officer in New Guinea from May 18 to June 10, 1944, through long hours of untiring devotion to duty and with utter disregard for enemy snipers and the hazards of his task he removed several hundred unexploded shells and duds with the assistance of a small detail. . ."

Corp. E. V. Ehrhardt

M. SGT. JOHN I. DOTTERER (then Tech. Sgt.), Syracuse, N. Y. —"At Hollandia, Dutch New Guinea, April 22-29, 1944, he worked long and faithfully to compile and transcribe important data on ammunition expenditures. His unfailing attention to duty made possible prompt and adequate resupply of munitions losses. . ."

The Ordnance Flags

Armament Preparedness Symbolized in Heraldry

RECENTLY two flags were added to the galaxy of colors significant of achievement in the winning of the war in which we are now engaged. One is the flag of the Ordnance Department of the Army; the other is the flag of the Army Ordnance Association. Both flags symbolize the close connection between the two organizations. Each is symbolic of the importance of armament and industrial preparedness for victory in the present war and for the maintenance of peace in the years to come.

The flag of the Ordnance Department consists of the time-established escutcheon of the Department, superimposed upon a crimson field. The device—crossed cannon, shell, and flame, and the words "Ordnance Department, U. S. A.,"—has been in existence since the early days of the Department which was established as a separate corps of the Army under the leadership of Col. Decius Wadsworth in 1812. Below the device is superimposed the motto "Armament for Peace." This expresses fully the time-honored function of the Ordnance Department.

The design and development of weapons and their production for our military forces are responsibilities which the Department has carried for more than 132 years. Those responsibilities for the future are greater than at any time in the past. As they are met, the motto of the Department will be fulfilled, for only through adequate armament strength can the security and peace of our country be assured.

The Ordnance Department escutcheon contains the Ordnance insigne, the oldest military device of the American Army. It was adopted about 1833 and since that time it has officially designated the Ordnance Department. Prior to its American adoption, it had been used by the British Grenadier Guards, the Royal Engineers, and the Royal Horse Artillery. After its adoption by the American Army it was used by the Artillery as well as by Ordnance until 1834, when the traditional crossed cannon was adopted by the Artillery. The Ordnance escutcheon (crossed cannon in circle, with shell and flame above) also appeared first in 1833 and since that time has been used on all Ordnance publications, docu-

The Flag of the Army Ordnance Association

The Flag of the Ordnance Department, U. S. Army

ments, and drawings. It is now the official seal of the Ordnance Department.

In this connection, it is interesting to recall another ordnance symbol—the broad arrow, long the crown mark of munitions of war in the British service, the earliest trace of which occurs in 1553 when Sir Thomas Gresham, founder of the Royal Exchange, brought gunpowder into England. The broad arrow was used as a distinguishing mark. The first ordinance establishing a crown mark appeared in the reign of Charles I. The mark was instituted to prevent illegal traffic in arms, and henceforward it was obligatory that all muskets and other weapons issued from the King's stores for land or sea service be stamped or engraved with the broad arrow. A Royal commission, appointed in 1633, was directed to mark all small arms and armor with the letter "A" and a crown, the hallmark of the Company of Armorers of London.

Like the shell and flame, the broad arrow has retained throughout the course of centuries its pristine meaning; namely, the acme of perfection. The Ordnance flag does not incorporate the broad arrow, since this is essentially a British symbol. The flag does combine in the Department's escutcheon both the crossed cannon and the shell and flame. In our service, the latter is indicative of the superiority of our military armament and of the integrity of all Ordnance operations relating to engineering, production, supply, and maintenance.

On the first page of this brochure is published a picture of the presentation ceremonies held in the Office of the Chief of Ordnance on March 2, 1944. On this occasion, Brig. Gen. Benedict Crowell, president of the Army Ordnance Association and special consultant to the Secretary of War (*right*), presented the Ordnance flag to Maj. Gen. L. H. Campbell, Jr., Chief of Ordnance (*left*). The flag now stands in his office at the Pentagon Building across the Potomac from Washington, D. C.

A FLAG of the Army Ordnance Association has also been designed and produced. Photographs of both flags in color are published on the preceding pages. The Army Ordnance Association flag consists of the well-known shield of the society on a field of blue. The shield is in traditional maroon. Below the shield is the motto "Industrial Preparedness for Peace." This is an adaptation of the slogan of the Association: "Pledged to industrial preparedness for war as our Nation's strongest guaranty of peace." It is a fitting companion to the flag of the Ordnance Department.

STUDENTS of the subject will be interested in the use of the blue field in the Association's flag. According to the best historical records, blue has long been identified with Ordnance heraldry. Blue is the predominant color of the arms granted to the Right Honorable and Honorable, the Board of His Majesty's Ordnance, on May 16, 1823. According to the Office of Heraldry of Great Britain, these are the specifications of the earlier device: *Arms:* Azure—three field pieces in pale, or; on a chief, argent, three cannon balls, proper. *Crest:* Out of a mural crown, argent, a dexter cubit arm, the hand grasping a thunderbolt, winged and enflamed, proper. *Supporters:* On either side a Cyclops, in the exterior hand of the dexter a hammer, and in that of the sinister a pair of forceps resting on the shoulder of each respectively, all proper. *Motto:* "Sua tela tonanti."

The Army Ordnance Association long has had need for its own flag. Hereafter, it will be displayed at all meetings, national and local, and will be available for the headquarters of all local chapters. Arrangements are now being made with Annin & Company, noted flagmakers, for sufficient copies of the original flag for these purposes. Officers of the local chapters are urged to display the Association's colors on all appropriate occasions. Under this banner, the growing forces of industrial preparedness will march forward. Theirs will be the privilege to marshal the manufacturing, technical, and scientific strength of our country for adequate national security. The two flags portray the joint trusteeship of the Ordnance Department of the Army and the Army Ordnance Association to assure victory now and peace in the future.

And above both flags there flies as always, the Stars and Stripes—shining symbol of freedom from tyranny for the past 168 years. The spirit of justice and mercy, the desire for peace without oppression, the willingness to unsheathe the sword in defense of liberty, which have been our national characteristics and the roots of our greatness, are reflected in Old Glory and well epitomized in the above lines by Mary Perry King. While all right-thinking men "pray an end of war" they also hope that America will be well prepared, if again necessary, "to stay the feet of conquest."

HYMN OF FREEDOM

Unfurl the flag of Freedom,
Fling far the bugle blast!
There comes a sound of marching
From out the mighty past.
Let every hill and hollow
Take up the valiant cry:
Where, beautiful as morning,
Our banner cuts the sky.
Free-born to peace and justice,
We stand to guard and save
The liberty of manhood,
The faith our fathers gave.
Then soar aloft, Old Glory,
And tell the waiting breeze
No law but Right and Mercy
Shall rule the Seven Seas.
No hate is in our anger,
No vengeance in our wrath;
We hold the line of freedom
Across the tyrant's path.
Where'er oppression vaunteth
We loose the sword once more,
To stay the feet of conquest,
And pray an end of war.

—MARY PERRY KING.

Smaller War Plants

They Have Played a Vital Rôle in Producing America's Ordnance

Capt. J. W. Ogden

"THE high and practical patriotism of the men and women of the — — company is inspiring and heartening. Your record will be difficult to surpass, yet the Army and Navy have every confidence that it was made only to be broken." That was the message received by an Ordnance contractor from the Under Secretary of War in 1942, announcing the award of the Army-Navy "E" for "high achievement in the production of war equipment." And at its peak this company was employing 223 people!

The real recipient of this award was American ingenuity and initiative. Very early in the present emergency the business of this company had fallen off to such an extent that there were only three employees, and one of these was a schoolteacher who worked on the books after classes. The owner began looking about and eventually reached the Ordnance Department. Since that first contact the company has been continually busy and has earned three 6-month stars for continued excellence of production. While outstanding in having earned the "E" (only three per cent of all contractors have received this honor) this company is typical of the vast majority of the small plants of the country which have played a vital rôle in helping the Ordnance Department fulfill its obligation to provide fighting material.

In the early days of this war much was heard of the British so-called "bits and pieces" system. Essentially it was based on the production of components in many small plants whose products were funneled to other points for assembly. It was born of necessity, and an important factor in its success was the fact that no plant was more than a few hundred miles from any other.

Our own requirements created the same necessity which was recognized early by the Ordnance Department. As a result, Ordnance contracting officers from the beginning have tried to seek out qualified small-plant capacity and bring it into the Ordnance program. This search started from the base of the records accumulated since the last war under industrial-mobilization planning. While the "bits and pieces" system was not directly applicable, it was paralleled locally through Ordnance district efforts in locating small-plant capacity for use by the larger plants as subcontractors. Something of the extent of this distribution will be indicated later.

It should not be supposed that Ordnance efforts in this direction were confined to subcontracts. To have stopped here would have been a neglect of talent and capacity. Just what was this reservoir which was so necessary to the war effort? The War Department for purposes of administration has defined a small plant as "an independent concern with less than 500 employees." This definition, applied to figures given in the May 1944 issue of the Survey of Current Business by the Department of Commerce, develops some interesting facts. For the two industry groups, iron and steel and their products, and automobiles and equipment—which by and large are the ones most suited to Ordnance production—these figures for 1939 show that ninety-six per cent of the firms in these groups are small plants.

Captain Ogden is chief of the Smaller War Plants Section, Legal Division, Office of the Chief of Ordnance.

During the past year and a half the Ordnance Department has averaged more than $100,000,000 a month in awards to small plants. As of June 30, 1944, of the 4,206 prime contractors, 2,840, or 68 per cent, were small plants. In addition to prime contracting, of course, the small plant has been of great importance as a subcontractor, and many plants ill-equipped to serve as prime contractors because of the complex nature of the item can do an outstanding job on a component or an operation. It is significant that 45 per cent of the Army-Navy "E" awards for outstanding performance have gone to small plants.

But there is a catch to this if we are thinking in terms of production capacity in small plants. This ninety-six per cent of the firms employs only twenty-seven per cent of the workers. Any ratio of productive capacity based on man power should also be adjusted to allow for the fact that the large companies tend to a higher degree of technology with a consequent greater per capita production rate. Even if any such adjustments should reduce the employment figure to twenty per cent, it is obvious that the small plant was a source that could not be overlooked.

AS the emergency developed, the fullest possible utilization of our economic resources coupled with absolute priority for the requirements of war were the cardinal elements which were to shape our wartime economic structure. In the early stages, however, many small plants failed or refused to recognize the imminence of such things as priorities and limitation orders. It was not uncommon for a contracting officer to find it necessary to put on a "sales campaign" to get people to bid. Most of those who had the foresight to take on ordnance production at that stage have been busy ever since. As a matter of fact, district records show that, as a result of their experience and development of the "know-how" so necessary to ordnance production, at least 170 companies have grown out of the small-plant category since their first order.

A few of these companies, because of peculiar conditions or outstanding management, had exceptional growth. An optical company, which in peacetime employed less than a score of people, repeatedly expanded its operations and established one of the outstanding records of grinding and polishing optical elements. At its peak, this company employed over 1,700 people. The magnitude of this accomplishment can be better judged when it is considered that at the beginning of the war there were only 234 precision optical workers in the country. There are several cases of small pyrotechnic companies which have increased their force from five to ten times. And practically all of the 170 companies mentioned above have at least doubled their number of employees.

For purposes of administration the War Department has defined a small plant as "an independent concern with less than 500 employees." This definition, applied to figures given in the May 1944 issue of the Survey of Current Business by the Department of Commerce, brings out some interesting facts. For two important industry groups—iron and steel and their products, and automobiles and equipment—these figures show that 96 per cent of the firms in these groups are small plants. This 96 per cent of the firms, however, employs only 27 per cent of the workers. Records show that as a result of increased experience and the development of the "know-how" so necessary to ordnance production, at least 170 companies have outgrown the "small-plant" category since their first order.

A number of small plants did outstanding jobs on difficult technical situations. One plant, undertaking the production of metallic belt links requiring very close control and a high degree of technical skill, not only made an excellent showing on its own production but was asked to supervise similar activities in another plant which was having difficulty. Another company, already producing brass cartridge cases very satisfactorily, became a leader in the development work on the steel-case program.

There are literally hundreds of these success stories, but it must not be supposed that all was "beer and skittles." The "flexibility" of the small plant is often referred to, and recent experience has justified this claim in many cases. But, if by flexibility is meant the ability to change to another type of production, the fact is that the decision to change is merely a declaration of war. The battle has not even started.

The prime responsibility of the Ordnance Department is to furnish fighting equipment of the right quality, in the right quantity, and at the right time to the men who will use it. The primary responsibility of any contracting officer, therefore, is to assure himself that the prospective contractor can and will produce. The so-called flexibility of the small plant was frequently accompanied by limited management. Because of the all-important time factor, the tempo for most companies was greatly stepped up over peacetime practice. While the quality of management was there, the quantity was sometimes spread very thin.

DIFFICULTIES were encountered even in the bidding stage. Ordnance has few items on its shopping list which have a commercial counterpart, and cost estimating is not a lucrative field for guesswork. In many small plants, estimating had been by rule of thumb based on years of experience in the same line, and the only record was in some one's memory. Because the product range was narrow, such a basis was usually reliable. However, when it became necessary to analyze ordnance drawings unrelated to past experience, many small organizations developed difficulties. Some, of course, could not even read the drawings, and it was pretty difficult to help when such was the case.

Even when the ordnance item was somewhat similar to the normal product, it was often found that cost records were inadequate or nonexistent. Going price information infrequently was available, and more than one contract was accepted on the basis of a guess in that neighborhood. If a bid was obviously too low and time permitted, the bidder was often invited to revise his price. For you can sink a man just as surely by giving him a contract on which he cannot perform as by giving him no business at all. And if he falls down, the Ordnance Department has lost his production as well as the time required to set up another producer—and time is of the essence in producing for war.

Once a contract had been secured, further difficulties developed, such as subcontracting problems—where to buy this material ("We never bought it before"); where to buy that component ("We can't make it ourselves, and we never had to provide anything like it before"). It is the prime contractor's responsibility, of course, to provide all material under the contract, and fundamentally it is up to him to find sources. But the district offices had much information at hand, not only from the Ordnance planning records but from recent experience with other contractors, and this information was always available.

Close scheduling and expediting frequently had not been necessary "before." Too often a company assumed that once it had placed the necessary subcontracting order it could sit back and wait for the materials to arrive on schedule. But to come upon the scheduled delivery date with no material to work with was a rude awakening.

NEW-equipment, tool, jig, and fixture design brought other problems. For many plants it was years since it had been necessary to design any jigs and fixtures. On the other hand, this was a field which often brought to light a latent creative genius. One company in the South with only the meager and simple equipment required for its normal product, steel reënforcing bars, received a contract for bomb trunnion bands. By means of subcontracting and some very clever jig design, this company not only made an outstanding production record at an exceptionally low cost but did it with unskilled labor.

Inspection difficulties also played their part. Many companies failed to appreciate at first that ordnance drawings meant what they said. The old cry, "it will work just as well if you allow another five-thousandths" was raised many times, but time and education eventually took care of this.

Sometimes just plain inertia gave the contracting officer gray hair. A company normally making custom truck bodies received an order for a production run for cargo bodies. The company, which was pretty badly down on its luck, was operated by three elderly gentlemen. Letter after letter from the contracting officer went unanswered and finally a personal visit was made. There was an antique typewriter in the plant but no one to operate it. Orders for materials had been placed accompanied by a childlike faith in delivery promises. Work had been started on the jigs but was proceeding in such a leisurely manner that it was hard to tell that any progress was being made.

In spite of the fact that he was in a critical labor area, the contractor was confident he could get the additional help he would need, although no action had been taken to locate it. The upshot was that an inspector was placed in the plant, and for a few weeks his value was measured by his ability to prod the contractor. The company was finally convinced of the need for action, and, though initial deliveries were delayed, subsequent records showed satisfactory production. That the contractor was not without ingenuity is evidenced by the fact that he persuaded an officer in charge of an adjacent construction project that it was to the advantage of the Government to use an idle crane to load his product on railroad cars for shipment. This free service stopped only with the completion of the construction.

It is true these difficulties were not confined to small plants. The big ones had them too. But they were intensified and magnified in the small plants. In the large plant, recognition that a problem existed often took care of it since experienced personnel were available for transfer to bolster the weak spots. Many small plants are "one-man" shops, and when the volume increases some facet of the work is likely to suffer. And, of course, time is lost in educating other men to take over these functions.

That small plants have played such a vital part in ordnance production is due primarily to their enthusiasm, ability, and ingenuity. Complementing the small plants' efforts are two steps taken by the Ordnance Department. In the first place, the district procuring offices make a very thorough check of a prospective contractor before an award is made. Ever foremost in the thinking of the contracting officer is his responsibility for production. At the same time he recognizes a responsibility to the bidder. The job is to fit the square peg into the square hole. Any contractor can find moral support in the thought that the Ordnance Department is confident of his ability to produce.

In the second place, once the award has been made, every resource of the district, backed by all the other elements of the Department, is brought to the assistance of the contractor to ensure production. Engineers and production men are available to assist in setting up control procedures. Much assistance in expediting, primarily the responsibility of the contractor, is given by the district. Subcontracting sources are located. Frequently the inspector, usually reviled by the uninitiated as the "bogeyman" of the contractor, is of inestimable help because of his training in the arsenals or experience on other contracts. There were numerous cases where the inspector performed many of the duties of a superintendent and saved the contractor months of floundering.

IF mechanical difficulties were expected, arrangements were made for visits to the arsenals or, in many cases, to other plants making the same item. The classic example of this sort of coöperation was in the case of parachutes for bombs. At the start of this program there were 156 contractors scattered all over the country, and with very few exceptions they were all small plants. Because of the critical nature of the item, an integrating committee was formed whose membership was composed of representatives of each of the contractors. And if ever there was a heterogeneous collection, that was it. There were hosiery manufacturers, corset makers, tent and awning people, and bedspread producers. In fact, when asked what his specialty was, one man replied, "carnations." It was true. He had been operating a nursery.

With this variety of experience and inexperience, it became apparent at the first meeting of the committee that some program of education and control would be necessary. Accordingly, an engineering subcommittee was organized, and one of the larger companies which had been in production for some time was asked to guide its activities. Incidentally, this company was one of those which had "grown up" since the start of the emergency, having increased its personnel from 135 to over 800. An intensive program was started. The doors of this company were open to any and all contractors who wished to see how production was being handled, a booklet was prepared with pictures and descriptions of each operation, and even movies were taken and the film made available to any member of the committee. As a result, the Ordnance Department was enabled to meet its delivery requirements. Months were saved which would have been wasted had individual contractors been permitted to "muddle through." It should be mentioned also that, as a result of this training and later experience, the average unit price has declined fifteen per cent.

An optical company, which in peacetime employed less than a score of people, repeatedly expanded its operations and established one of the outstanding records of grinding and polishing optical elements. At its peak, this company employed over 1,700 people. The magnitude of this accomplishment can be better judged when it is considered that at the beginning of the war there were only 234 precision optical workers in the country. A brickyard is now heat-treating and annealing a variety of steel products although the plant had never been used for metalworking until March 1942. Brick kilns are of the type used 50 years ago, and the fuel is coal, fired by hand. Yet only 20 out of 75,000 end connectors for tank tracks made there have been rejected by the Ordnance inspector.

Over the past year and a half the Ordnance Department has averaged better than $100,000,000 a month in awards to small plants. As of June 30, 1944, of the 4,206 prime contractors, 2,840, or 68 per cent, were small plants. And if we transpose to the small-plant side of the ledger those 170 plants which "grew up," this figure becomes 75 per cent. In any case, it is obvious that Ordnance has had extensive experience with small plants.

In addition to prime contracting, of course, the small plant has been a vital part of the program as a subcontractor. Many plants are ill-equipped to serve as prime contractors because of the complex nature of the item but can do an outstanding job on a component or an operation; others prefer to take subcontracts only. In deference to the already overworked clerical staffs of the prime contractors, no attempt has been made to obtain complete figures on the extent of this subcontracting, but from a number of spot checks it appears that at least fifty per cent of the subcontractors are small plants and that these subcontracts aggregate at least twenty-five per cent of the prime-contract value.

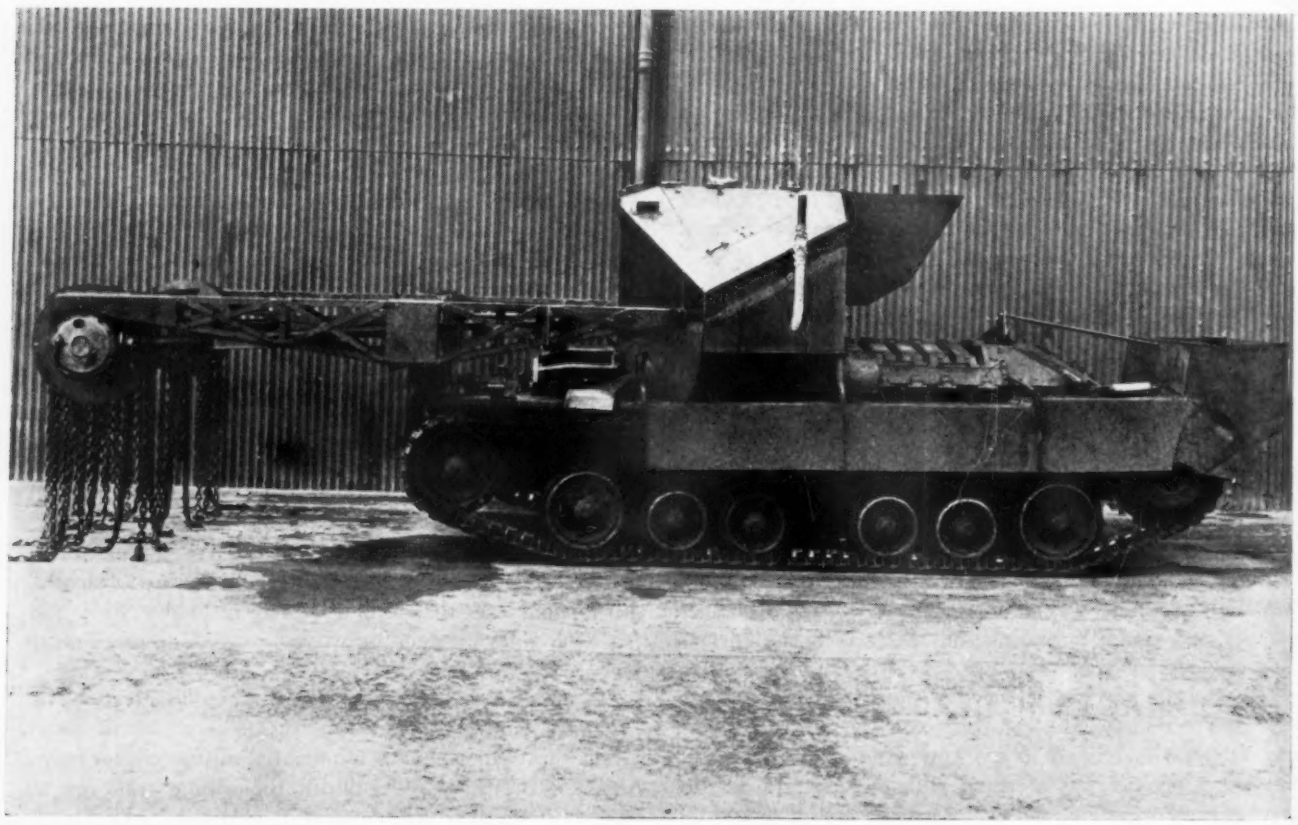
Out in the Middle West there is a brickyard, referred to by its president as "the hole in the hillside." This company is now heat-treating and annealing a variety of steel products. This plant had never been used for working with metals until March 1942. Brick kilns are of the type used fifty years ago, and the fuel is coal, fired by hand. And yet only 20 out of 75,000 end connectors for tank tracks made there have been rejected by the Ordnance inspector. The corset manufacturer who turned to parachutes for bombs was perhaps not so far off his beaten path, but for a brickyard to begin heat-treating steel required at least a degree of courage. As the plant manager put it, "We knew it could be done, so we experimented until we found out how." And therein lies the reason for most of the success of the small plants.

It is significant that forty-five per cent of the Army-Navy "E" awards for outstanding work have gone to small plants.

EDITOR'S NOTE.—Maj. Gen. L. H. Campbell, Jr., Chief of Ordnance, said on January 19, 1944: "America, to remain strong, must protect her own industrial supremacy, for only as American industry thrives during the coming years will our military strength be able to meet its continuing obligations."

British Invasion Vehicles

The "Wasp," shown above, is one of Britain's new flame-throwing vehicles and consists of a flame gun attached to an armored Bren gun carrier. A larger model flame thrower is carried by a Churchill tank. Below is a chain flail or "scorpion" attached to a British Valentine tank chassis for use in detonating buried land mines (British official photographs).



Lighter Weapons from Magnesium

The White Metal Finds Increasing Use in Ordnance Matériel

Maj. C. H. Corey

The importance of air-borne attack and jungle combat in World War II has necessitated the development of weapons light enough to be carried in quantity by airplane or manhandled over steep, slippery trails. Magnesium, which is fifty per cent lighter than aluminum and has admirable properties of strength and endurance, is helping solve the problem of lightweight armament, and greater developments are forecast for the future.

THE present war has created a demand and necessity for lightweight ordnance matériel never before equaled, due largely to the fact that never before has it been necessary to transport so huge a volume of war material over such great distances. Practically every piece of ammunition and fighting equipment used in combat is carried thousands of miles by boat, amphibious vehicle, and airplane before it reaches the various theaters of operation. After that, it is carried still farther by man, motor vehicle, and airplane over mountains and through jungles.

Whether air-borne or man-borne, the advantages of lightweight matériel are the same and can mean the difference between winning and losing a battle. For example, in mountain and jungle warfare man is the chief carrier of fighting equipment. If the weight is excessive, either maneuverability is decreased, or fighting man power is sacrificed to provide carriers, or necessary ammunition and weapons are left behind.

A good indication of the increasing importance which is attached to lightweight metals is shown in the following table by the percentage increases in U. S. production of both aluminum and magnesium between the years 1939 and 1943.

Metal	*1939*	*1943*	*Increase*
Magnesium	10,000,000 lbs.	390,000,000 lbs.	3,800%
Aluminum	328,000,000 lbs.	1,840,000,000 lbs.	470%

The demand for magnesium at the beginning of the war for use in military aircraft and in incendiaries increased so much more rapidly than production capacity that the Ordnance Department was not permitted its use for structural applications prior to the spring of 1943. At present, the Ordnance Department uses only approximately five per cent of the total production of magnesium for structural purposes; however, it would appear from the wide interest shown in magnesium by Ordnance engineers that this figure will be greatly increased.

Aluminum is 50 per cent heavier than magnesium; structural steel is 440 per cent heavier than magnesium; and brass is 470 per cent heavier than magnesium. If lightweight structures are required, it is generally easier to achieve that objective with lightweight metals. The aircraft industry, which uses mostly aluminum and magnesium alloys, is an example. It is not impossible to build as lightweight structures from high-strength heavier materials, but there is a minimum limit of thickness below which even the strongest material may not be used with safety because of the danger of buckling and corrosion.

Magnesium-alloy castings (sand, permanent-mold, and die) have practically the same mechanical properties as aluminum-alloy castings and are one-third lighter in weight. This is shown by the following comparison of sand-cast magnesium alloy, Dow C-HT or American Magnesium Corporation AM-260-T4, with conventional sand-cast, high-strength aluminum alloy QQ-A-601, Class 4 (195-T4). The table below shows minimum test-bar properties.

Characteristic	*AM-260-T4 (C-HT)*	*QQ-A-601, Class 4, HT2 (195-T4)*
Ult. tensile—p.s.i.	32,000	29,000
Tensile yield—p.s.i.	10,000	13,000
Comp. yield—p.s.i.	13,000	14,000
Endurance limit—p.s.i.	12,500	6,000
Ult. shear—p.s.i.	18,000	23,000
Elongation—per cent	6	6
Brinell hardness	63	65

The higher endurance limit and the considerably greater spread between the yield and tensile strengths of the magnesium alloy, together with its lower modulus of elasticity, indicate its superiority over the aluminum alloy for applications subjected to shock loads.

A SAMPLE 60-mm. mortar base plate was made from AM-260-T4. Others of identical design were made from aluminum alloy QQ-A-601, Class 4 (195-T4). Tests indicate that the magnesium-alloy base will withstand as much rough service as the present standard steel base made of welded plate. The weight of each mortar plate is as follows: steel, 12.80 pounds; aluminum, 10.47 pounds; magnesium, 7.52 pounds. The excellent preliminary results on the 60-mm. base plate have encouraged an extension of the test program to include many of the heavier mortar base plates. One of these will involve a one-piece casting weighing approximately 600 pounds in magnesium compared with approximately 1,300 pounds in steel weldment. The 700 pounds of weight saved means increased offensive power by any of several methods—such as greater maneuverability, less man power for handling, or a larger load of ammunition. These cast-magnesium bases will be competitive costwise with the welded steel bases.

The 600-16 artillery carriage wheel is made of sand-cast magnesium alloy, Specification 57-74-1E (Dow H-HT or American Magnesium AM-265-T4). The wheel is entirely cast magnesium alloy except for the steel bolts, nuts, and the hub assembly. It weighs approximately nineteen pounds compared with approximately thirty-two pounds for the conventional steel wheel. Twelve of these wheels have satisfactorily withstood all rigid service tests required of artillery

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wheels. Due to the good test results on this size wheel, the test program is being enlarged to include additional sizes of artillery wheels.

In die castings the picture is practically the same; *i.e.*, magnesium castings equal the strength of aluminum castings and are one-third lighter in weight as illustrated in the following table showing typical test-bar values.

Characteristic	*Magnesium: Spec. 57-74-3 (R or AM-263)*	*Aluminum: Spec. QQ-A-591, Class 1 (#13)*
Ult. tensile—p.s.i.	34,000	33,000
Tensile yield—p.s.i. ...	22,000	18,000
Fatigue—p.s.i.	14,000	15,000
Elongation—per cent ..	3	2

Magnesium-alloy die castings are under test for several applications in fire-control equipment and as ammunition components where quantity production is essential.

MAGNESIUM and its alloys have very good resistance to atmospheric corrosion—better, in fact, than a number of aluminum alloys and ordinary steel. The chart on page 459 shows a group of wrought aluminum-alloy, magnesium-alloy, and structural-steel corrosion test specimens after they were exposed in various atmospheres throughout the United States and to alternate immersion in sea water. The number under each test specimen represents the percentage loss in tensile strength after exposure to the condition indicated. Note that the unprotected magnesium alloys are practically as good as the unprotected aluminum alloys in all exposures, including sea water, and several times superior to unprotected structural steel.

It is interesting to note the very poor corrosion resistance of the two magnesium-alloy AM 52S-H specimens in tidewater. They are representative of magnesium alloys of several years ago when it was not commercially possible to remove the small amounts of detrimental iron and nickel. This alloy today, known to industry as AM-C52S-H, with the iron and nickel reduced to extremely low concentrations, has superior corrosion resistance to magnesium alloy AM3S-H and aluminum alloy 24S-T (QQ-A-355A) and is the equal of aluminum alloys 3S (QQ-A-359A) and 17S-T (QQ-A-353A).

The results shown in the chart were confirmed several months ago at the Dow Chemical Company seacoast test station. Corrosion test panels of all types of alloys of aluminum, magnesium, steel, and nickel had been exposed for as long as 2 years at distances 80 feet and 800 feet from the sea. The most impressive fact was that the unprotected steels (except stainless steels) were severely rusted after several months' exposure, whereas most unprotected aluminum, magnesium, and nickel-base alloys were in a relatively unaffected condition.

That magnesium alloys are a fire hazard and ignite easily is true—provided the alloys are in powder or fine-particle form. In some respects it is a credit to magnesium to be so versatile that it can be used for strong structural applications as well as for incendiary purposes. A fire hazard exists where fine magnesium particles, such as grinding dust, are formed by a cutting operation without adequate heat distribution. This hazard may be eliminated by grinding under oil or by exhausting the grinding dust and precipitating it under water. There is some danger of fire in machining and drilling magnesium if the tool is dull and sufficient heat is generated to bring the chips up to the incipient fusion temperature.

Thousands of aircraft oil tanks have been made of approximately 0.040-inch magnesium-alloy sheet, torch-welded at all joints with ⅛-inch diameter magnesium-alloy welding wire. If there were any danger of this thin-gauge sheet or the small pieces of wire catching fire, the welders certainly do not know it since they melt the wire down to a length of two inches until it can no longer be held in the fingers and work as nonchalantly as if they were welding aluminum or steel.

A convincing demonstration is to fill a magnesium-alloy tank with gasoline and burn a hole in the side with a blowtorch. The gasoline burns out, but the magnesium tank is no further damaged. Incidentally, the gasoline tanks of the British Spitfire airplane are made of magnesium alloys.

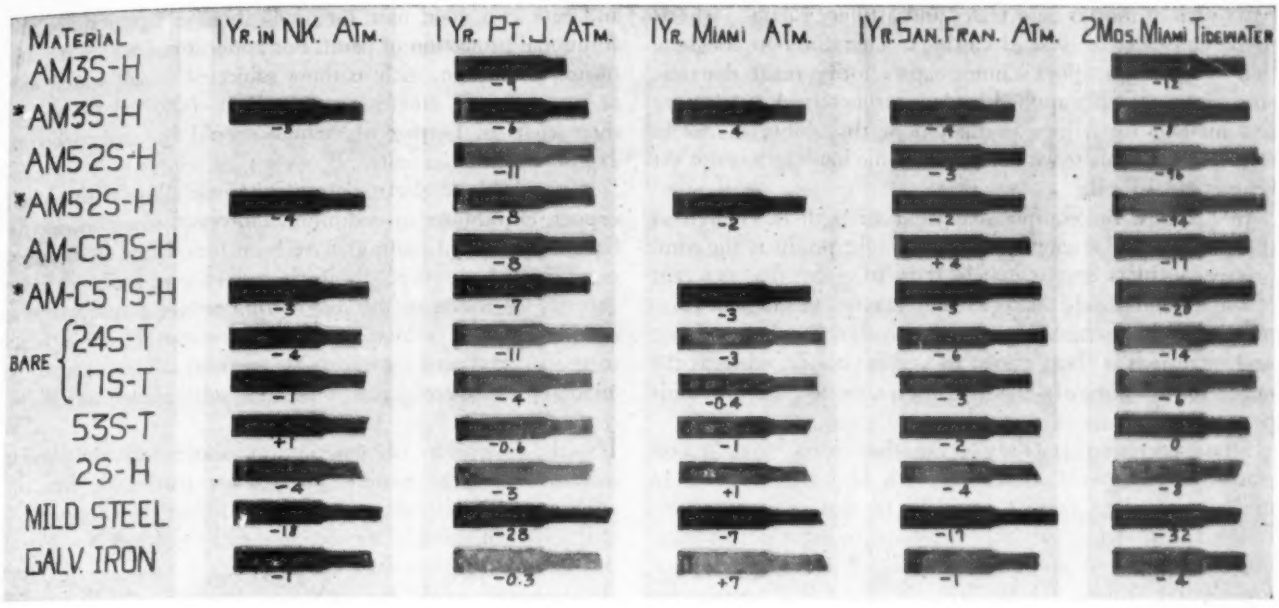
Magnesium alloys are easily spot-welded, arc-welded, and flame-welded. Magnesium-alloy wrought products have certain advantages over aluminum-alloy wrought products when arc or flame welding is required. Generally, wrought-magnesium alloys can be heliarc-welded with a loss in strength at the weld of only ten to twenty per cent of the parent material, whereas arc- or flame-welded aluminum alloys lose approximately forty per cent. Heliarc welding can be done manually or automatically and does not require the use of flux. This is an important consideration when it is necessary to weld sections together to form an inclosure inaccessible for the removal of excess flux.

The Ordnance Department is experimenting with magnesium-alloy trails and spades for one type of the 105-mm. howitzer. The trails are made from three extruded shapes heliarc-welded on the neutral axis the entire length of the trail. The spades are made from magnesium-alloy plate and are heliarc-welded to the trails.

Magnesium alloys can be extruded into complicated shapes. This process permits the design of shapes having a cross section wherein the material is distributed most efficiently to give a maximum stiffness-weight or strength-weight ratio. Tests are being made on a hollow, extruded magnesium-alloy recoil cylinder for the 37-mm. gun. Several parts are combined into one resulting in a saving of costs, man-hours, assembly problems, and considerable weight. The cradle for a 20-mm. aircraft cannon will be made as a magnesium-alloy extrusion. It will replace a magnesium-alloy casting, resulting in higher strength for the same weight.

THE modulus of elasticity of magnesium alloys is 6,500,000 compared with 10,300,000 for aluminum alloys and 29,000,000 for steel. The low modulus of magnesium is more generally a credit than a discredit to the metal. It is an inherent property which gives the metal a relatively high modulus of resiliency, a desirable characteristic of any material used for structural applications subjected to shock loads.

A low-modulus material will deflect farther under a given load than a material of higher modulus. In castings, which are usually massive, deflection is generally not important, so that the low modulus is ordinarily not a factor. In wrought-magnesium shapes, sufficient stiffness can be provided generally with a large weight reduction if there is no limitation to over-all dimensions. This is done by taking advantage of the fact that stiffness increases as the cube of the depth, and the strength as the square of the depth of section. The following table compares the relative weights of rectangular



ATMOSPHERIC AND ALTERNATE IMMERSION CORROSION TESTS OF MAGNESIUM AND OTHER METALS

Legend: The tests marked with an asterisk (*) were given American Magnesium Corporation treatment "A" (chrome pickle). "N.K." stands for New Kensington, Pa., and "Pt. J." for Point Judith, R. I. The number under each test specimen represents the percentage loss in tensile strength after exposure to the condition indicated. The top six tests were made with magnesium alloys; the next four with aluminum alloys; the last two with mild steel and galvanized iron respectively.

magnesium, aluminum, and steel structural sections of equal stiffness and equal strength:

	Magnesium	*Aluminum*	*Steel*
Equal strength	26	37	100
Equal stiffness	37	51	100

The Ordnance Department is using millions of pounds of magnesium-alloy tubing for the 4.5-inch aircraft rocket launcher shown mounted under the wings of a Republic P-47 Thunderbolt on page 467. It was selected in place of aluminum-alloy tubing because of weight limitations.

A peculiar example of where magnesium is indicated over aluminum or steel is in rammer staffs. These staffs are used in multiple sections for cleaning and loading the 8-inch gun and the 240-mm. howitzer. Soda ash used in the cleaning solution attacks aluminum but not magnesium. Also, magnesium-alloy tubing staffs will be lighter in weight than aluminum alloy or steel staffs of the same stiffness, as shown below.

Matériel	*Outside diameter*	*Wall thickness*	*Weight per foot*
Magnesium	2½"	⅛"	0.717 lbs.
Aluminum	2¼"	⅛"	1.01 lbs.
Steel	1¾"	0.065"	1.478 lbs.

Preliminary tests indicate that complete magnesium-alloy staffs will be satisfactory and have shown that the screw threads serve their purpose much better than expected.

Magnesium alloys are in general approximately twenty per cent lower in shear strength than aluminum alloys. Accordingly, it is advisable to provide more thread area in screw holes than is normally provided with aluminum, brass, or steel. When studs are used, a generally accepted standard is to have the active thread length approximately 3 times the stud diameter. When an increase in thread length is not feasible, an increase in thread diameter may be an alternate solution. A coarse thread is preferable, such as the American National Coarse Series or the British Standard Whitworth Thread. Threaded magnesium parts do not seize.

MAGNESIUM alloys have a relatively high fatigue strength as shown by the following comparative endurance limits based on 500,000,000 cycles of completely reversed stress: Cast magnesium, 11,500 p.s.i.; cast aluminum, 7,000 p.s.i.; wrought magnesium, 17,000 p.s.i.; wrought aluminum, 17,000 p.s.i.; wrought brass, 14,000 p.s.i.; wrought steel, 33,000 p.s.i.

Fatigue strength is that alternating stress which can be endured for an infinite number of reversals. In order that maximum advantage may be taken of the high endurance of magnesium alloys, special precautions should be taken to avoid stress concentration due to notch effect and surface effect. The risk of fracture by alternating stress is greater than by static stress mainly because of the difficulty of making accurate stress calculations. In the design of ordnance matériel, fatigue strength is relatively important since practically every piece of equipment is subjected to alternating stresses produced by gunfire and by transportation over long distances and rough terrain. Magnesium-alloy castings and tubing are under test for several small-arms tripods and standards chiefly because a material with a high fatigue-weight ratio is demanded.

Magnesium alloys are relatively notch sensitive which explains the low values obtained from notched specimens used in Charpy and Izod impact tests. Because of this notch sensitiveness, designers should avoid such things as sharp threads, sharp corners, and abrupt changes in section thicknesses which contribute toward stress concentration.

The exceptionally good fatigue resistance and damping capacity of magnesium alloys permit heavily impact-stressed

parts such as mortar base plates and artillery carriage wheels to be constructed as sand castings. Therefore, to conclude that magnesium alloys cannot satisfactorily resist dynamic stresses or suddenly applied loads is erroneous. A satisfactory test method for a true evaluation of the ability of notch-sensitive materials to withstand dynamic loading has not yet been standardized.

In castings, the compressive yield strength is as high as the tension yield strength, but in wrought products the compressive yield is approximately sixty to eighty-five per cent of the tensional yield strength. The maximum range of compression yield strength for magnesium-alloy forgings, tubing, and extrusions is from 25,000 to 35,000 pounds, whereas the range for aluminum alloys is from 40,000 to 70,000 pounds per square inch.

Stress corrosion cracking is another name for "season cracking" commonly associated with high-zinc brasses. In magnesium alloys, there is generally no danger of stress corrosion cracking in castings, extrusions, rod, tubing, or forgings because these products are made at elevated temperatures. Most instances have been in cold-rolled tempers of sheet alloys of the magnesium-aluminum-zinc type subjected to continuous applied or locked-up stresses in excess of approximately 15,000 p.s.i. Welded structures are a possible source of locked-up stresses of this magnitude, for which reason stress relieving is always recommended. Alloys of the magnesium-manganese type, such as AM3S or M, are not susceptible to stress corrosion cracking in any form or product. It is, therefore, not necessary to stress-relieve welded structures of this alloy. In stress corrosion cracking the fracture is generally intracrystalline. Magnesium alloys are not subject to intercrystalline corrosion. The properties of magnesium alloys are not adversely affected at temperatures as low as 108 degrees below zero, Fahrenheit.

In column design, it is essential to increase the sections geometrically. A magnesium column shows to best advantage over the medium l/r (length divided by radius of gyration) range, between 60 to 150. In the short-column range, below 60 the low compressive yield strength is the limiting factor, and above 150 the low modulus prevents appreciable weight saving.

ALL magnesium alloys can be machined at higher speeds and with greater economy in time and power than any other metals. This is due to the low cutting pressure required and to the high thermal conductivity of the metal, both of which contribute toward preventing the cutting tool from becoming overheated. Based on power consumption, they require one-half to two-thirds the power required for cutting aluminum alloys or brass, one-third that for cast iron, and one-sixth that for steel. There are no important differences in the machining characteristics of cast or wrought alloys, so that the same cutting speeds and the same tools can be used irrespective of the alloy and the condition of the material.

Magnesium alloys, without any protection, are exceptionally stable in all ordinary inland atmospheres. Some surface attack of the etching type does occur, but it is a uniform etch and does not follow the grain boundaries. Nevertheless, where atmospheric attack or frequent exposure to moisture or sea water is present under actual conditions of service, all alloys should be provided with good protective coatings. Magnesium-alloy products are usually supplied with a chrome pickle treatment. It provides protection from tarnishing and corrosion during shipment, storage, and machining, and acts as a good base for applications which require the additional protection of paint. For applications which require utmost protection, such as those subjected to salt water, one or two coats of zinc-chromate primer, followed by one to three coats of lacquer or enamel should be applied before exposure to the elements.

It is possible to electroplate magnesium alloys with nickel, copper, chromium, or cadmium. However, since no electrolytically produced coatings have been found free from pores, none is used commercially in the presence of moisture since galvanic corrosion of the magnesium would result. Metallic coatings applied on magnesium by spraying are not satisfactory for the same reasons. Magnesium alloys cannot be anodized commercially as is possible with aluminum alloys.

IN the assembly of magnesium alloys with dissimilar metals, where the joining surfaces are reasonably flat, the application of zinc-chromate primer to each faying surface will give satisfactory protection against corrosion. Where the joining surfaces are not flat, after priming with zinc-chromate primer the parts should be assembled with a heavy sealing compound such as various brands of zinc-chromate putties.

For joints such as assemblies to engines which require a higher degree of tightness and compression strength than afforded by sealing compounds, an approved gasket material is recommended. Hard fiber, synthetic rubber, rubber-bound asbestos, plastics, and kraft paper impregnated with zinc chromate may be used. When steel bolts or screws are used in contact with magnesium, the steel should be cadmium- or zinc-plated. Additional protection can be provided with the use of an aluminum-alloy washer, preferably of the aluminum-magnesium type.

Certain types of sealing compounds and gaskets which may promote corrosion by drawing moisture into the joint by capillary action are to be avoided. Examples are ordinary putties and plastic sealing compounds containing iron oxide, red lead, white lead, fibrous materials such as asbestos paper, asbestos cloth, cork, felt, and nonimpregnated paper.

Ample facilities now exist for the production of all types of magnesium-alloy products such as forgings, extrusions, tubing, sheet, and all types of castings.

The Ordnance Department now considers magnesium for design purposes in the same category as steel, aluminum, copper-base alloys, or other common materials. Every effort is being made to utilize each of these materials to obtain the maximum advantage of their individual engineering characteristics. Army specifications have been prepared covering certain magnesium products, and, as the need develops, additional specifications will be provided to cover any type or characteristic of magnesium or its alloys.

As is the case with most new materials—and magnesium is essentially a new material from a point of view of engineering construction—considerable development and test work must be done before they can be considered for war matériel. This development work is generally of greater necessity in military than in industrial applications since the performance and effectiveness of war matériel must be assured before it is issued to troops that are scattered over the entire world. The Ordnance Department has made rapid progress in the use of magnesium, and, as may be inferred from the examples shown, a considerable amount of additional test work is under way, much of which looks encouraging from preliminary test reports.

New Arms for America

AMIDST the "fog of war," the secrecy necessarily imposed during actual military operations, and the persistent and spectacular enemy threats of new developments and "secret weapons," it is quite possible that some American citizens may have occasionally wondered if the U. S. Army was fighting today's bitter battles with last month's armament.

If this has ever been the case, such doubts have been allayed once and for all by the release, during recent weeks, of War Department information about many powerful new weapons and combat equipment of all kinds including new types of tanks, tank destroyers, amphibious vehicles, aircraft, rockets, chemical-warfare weapons, and numerous others.

Among the more important developments are eight new types of ordnance matériel. These are: (1) the General Sherman M4 medium tank armed with the powerful new 76-mm. gun known as the "Hole Puncher"; (2) the M4 tank equipped with the 105-mm. howitzer, representing the greatest firepower yet achieved in a fast-moving, maneuverable medium tank; (3) the 19-ton light tank M24 armed with a 75-mm. gun, three machine guns, and a smoke mortar, giving this 35-mile-an-hour vehicle the firepower of former medium tanks; (4) the air-borne tank M22, armed with a 37-mm. cannon and a caliber .30 machine gun and designed to be carried by glider to effect tank concentrations behind enemy lines; (5) the 76-mm. gun motor carriage M18—a 20-ton, high-speed tank destroyer mounting the 76-mm. gun and a caliber .50 machine gun in a turret with 360-degree traverse; (6) the 90-mm. 31-ton gun motor carriage M36, the fastest major-caliber tank destroyer in the world whose 24-pound armor-piercing projectile can rip through any enemy tank; (7) the M29C amphibious cargo carrier, known as the "Water Weasel"—a 14½-foot-long, full-track-laying vehicle which can travel over snow or mud as well as in water; (8) the armored utility car M20—a high-speed, 6-wheel-drive, cross-country vehicle for field commanders directing the advance of motorized units.

Other recent Ordnance developments are the jungle mortar, the tankdozer, incendiary armor-piercing ammunition, "spike bombs," and a superexplosive for rockets, all of which are described under "New Developments" on page 489 of this issue.

The big news in aërial warfare is still the B-29 Superfortress bomber, but new types of fighting aircraft include the Douglas A-26 Invader, an improvement of the A-20; the Bell P-63 Kingcobra fighter, a larger version of the P-39; the Bell P-59A "Airacomet" jet-propelled plane; the Northrup P-61 Black Widow twin-engined night fighter; and the use of rockets as part of the armament of the P-47, P-38, P-39, and P-51 fighter planes.

The British have developed various types of mine-destroying and flame-throwing vehicles, such as those shown on page 456, and the U. S. Marines have employed flame-throwing tanks against the Japanese on Saipan Island.

These are weapons that already have been in use against the enemy, but it is safe to assume that there are many others even more effective, waiting to do their part when the strategic moment arrives. (Accompanying illustrations are from Ordnance, Air Forces, and Acme photographs.)

Greater Firepower for the M4 Medium Tank

Shown above is the General Sherman M4 medium tank armed with the powerful new 76-mm. gun known as the "Hole Puncher" which fires a 15-pound projectile at high muzzle velocity. The 33-ton M4 tank below mounts a 105-mm. howitzer in a full-rotating turret and 3 machine guns. This is the first time a gun of such caliber has been installed in a medium tank.

Two New High-Speed Light Tanks

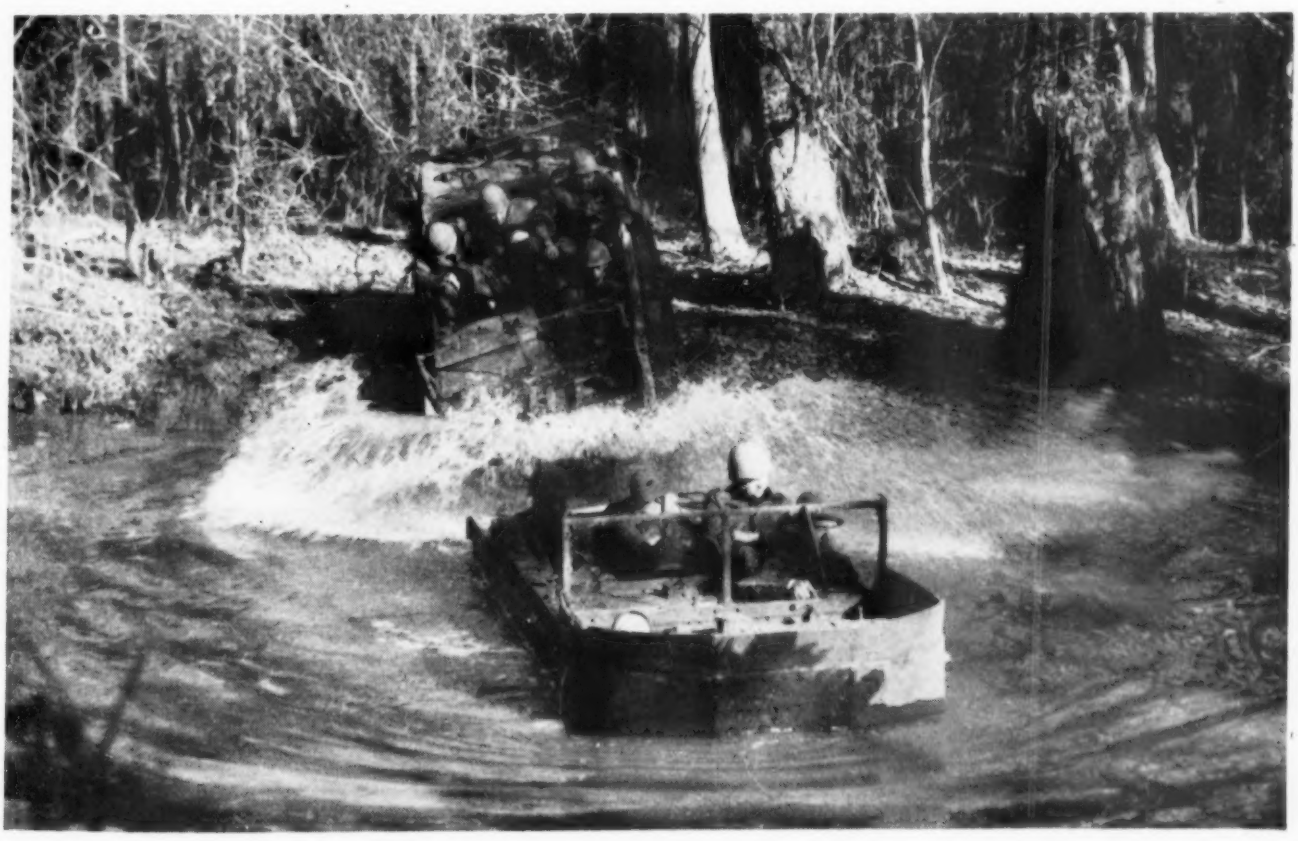
The new light tank M24, shown above in simulated combat, weighs 19 tons, has a speed of 35 m.p.h., carries a 4-man crew, and mounts a 75-mm. gun and 3 machine guns. It has torsion-bar suspension. Below is the new air-borne tank M22 known as the "Locust." Designed to be carried by glider, it has a speed of 40 m.p.h. and mounts a 37-mm. cannon and a machine gun.

The Army's Latest Tank Destroyers

The 90-mm. gun motor carriage M36, above, is a tank destroyer firing a 24-pound armor-piercing projectile from its high-velocity gun. Weighing 31 tons, it has a speed of 30 m.p.h. and can cross a 7½-foot trench. Below is the 76-mm. gun motor carriage M18, a 20-ton, low-silhouette tank destroyer with a speed of 50 m.p.h. It has torsion-bar type bogie suspension.

The "Weasel"—Cargo Carrier for Land and Water

The new cargo carrier M29, the "Weasel," shown above, was developed for use over snow, mud, and other treacherous terrain and can carry 3 passengers or cargo in addition to the driver. Below is its amphibious brother, the "Water Weasel," M29C with a longer, boat-shaped body and hinged rudders. The tracks give propulsion on both land and water.



New Developments in Army Fighter Planes

The Bell P-63 Kingcobra, above, is a larger, more powerful version of the P-39 Airacobra which it will replace. It has a 50 per cent greater combat radius than the P-39, a service ceiling of about 35,000 feet, speed of 400 m.p.h., new 1,500-horsepower Allison 2-stage engine, and a low-drag, laminar-flow wing. Below is the Republic P-47 with new "bubble" canopy.

Heavier Firepower for Aërial Warfare

The Northrup P-61 Black Widow night fighter, above, weighs over 25,000 pounds, is powered by two 2,000-horsepower Pratt & Whitney engines, is armed with 20-mm. cannon and cal. .50 machine guns, and carries the latest night-fighting devices. The Republic P-47, below, is armed with 8 cal. .50 machine guns and 6 rocket launching tubes under the wings.

New Vehicles for the Combat Theaters

The armored amphibious "Water Buffalo," above, armed with a 37-mm. cannon and several machine guns, has proved most effective in the invasion of Japanese-held islands. The new high-speed, armored utility car M20, below, is used by Army field commanders. It carries a 6-man crew, is equipped with 2 radios, and is armed with a cal. .50 machine gun.

The Age of Chivalry

The Influence of Armament on World History - III

Maj. Gen. J. F. C. Fuller

THE barbarian invasions of the Roman world influenced the course of history as profoundly as did the differences between Latin and Greek civilization. In the Western Empire, these incursions led to the disappearance of the Roman legion and with it the pagan order it sustained and in consequence compelled the Latin Church to build upon barbarism; but in the Eastern Empire, because there was no permanent military collapse, the pagan order lived on to become Christianized. In the one, military organization disappearing, valor in its most primitive form possessed the soldier. In the other, military organization being vastly improved, the soldier's intelligence was appealed to. The result was that, whilst in the West tactics and armament deteriorated, in the East they advanced until a perfection was reached, not again to be approached until the nineteenth century.

In the West the barbarian invasions, by forcing the Romans to adopt a mobile defensive policy, compelled the substitution of cavalry for infantry. By the middle of the fifth century the legion vanishing, the horse soldier was left as the one operative arm. Thus it came about that the sword and *pilum* gave way to the lance and bow. At the Battle of Châlons, fought in 451 between the Romans and Visigoths under Aetius and Theoderic and Attila's horde of Huns, lancer and horse-archer met horse-archer and lancer, the infantry playing the part of onlookers. Except as foragers, pillagers, and light troops for forest and mountain fighting, infantry were useless. Armor was little worn, partly because of its cost, partly on account of deterioration in the armorer's art, but mainly because it impeded mobility. When it reappeared, as it did in the sixth century, it was in the form of the mail shirt (byrnie), which was more pliant and comfortable than ill-fitting plate.

In the West, at this date, as Lecky points out, "it would be difficult to conceive a more frightful picture of society than is presented by the history of Gregory of Tours (538-594); but that long series of atrocious crimes, narrated with an almost appalling tranquillity, is continually interspersed with accounts of kings, queens, or prelates, who, in the midst of the disorganized society, made the relief of the poor the main object of their lives." [1]

It is in this contradictory compatibility—the essence of practical Christianity—that a new epoch took root, to sprout into two complementary yet antagonistic stems. The first was the Church of Christ, in which the people, now sunk in abject fear and helpless and without an ideal to lean upon, discovered a new moral purpose in their lives. The second was the new social order created by feudalism, which provided the security in which this purpose could fructify.

Though without armor there could have been no feudal overlord—for not only did it give its wearer personal security but it differentiated him from all unarmored men—without the castle there could have been no feudal system, for it was the castle which gave permanence to the knightly caste. This was the greatest military contribution of the Crusades: they put Western chivalry in touch with the superb castles and fortified cities of the Eastern Empire.

As war teaches men how to die bravely, war is the school of heroism: such was the pagan ideal. But as death is the portal of the life eternal, war must also be the school of righteousness, otherwise death can lead only to eternal damnation: such is the Christian outlook. Thus the classical soldier is transformed into the idealized Christian knight of chivalry, "uniting all the force and fire of the ancient warrior with something of the tenderness and humility of the Christian saint . . . and although this ideal, like all others, was a creation of the imagination not often perfectly realized in life, yet it remained the type and model of warlike excellence to which many generations aspired; and its softening influence may even now be largely traced in the character of the modern gentleman." [2]

HAVING ennobled the fighter, the next task was to restrict his activities by sanctions and rules. The first step taken toward this end was the establishment of "The Peace of God" *(Pax Dei)*, which is first heard of in the year 990. Its aim was to protect ecclesiastical buildings, clerics, pilgrims, women, and peasants from the ravages of war; also cattle and agricultural instruments. The second step was "The Truce of God" (*Treva Dei)*, initiated by the Synod of Elne in 1027. According to it, all warfare was suspended from noon on Saturday until dawn on Monday. Later, this truce was extended from Wednesday evening to Monday morning. Later still, in 1095, at the Council of Clermont, Pope Urban II—the initiator of the Crusades—"proclaimed a weekly truce for all Christendom, adding a guarantee of safety to all who might take refuge at a wayside cross or at the plow." [3]

The means of enforcing this truce were religious sanctions—excommunication and interdict—and though the results were meager, these sanctions did effect something, for in the eyes of Christendom they branded the aggressor as the culprit.

A collateral restriction arose out of the feudal system. It also took two forms. The first was that war was restricted to the nobility and hedged in by codes of honor, and the second was the introduction of ransom—the price at which a prisoner redeemed his life or freedom, a city secured immunity from sack, or a ship was repurchased by her captors.

General Fuller is author of the following works, among others: "On Future Warfare," 1928; "India in Revolt," 1931; "Lectures on F. S. R. II," 1931; "Lectures on F. S. R. III (Operations between Mechanized Forces)," 1932; "War and Western Civilization, 1832-1932," 1932; "General Grant (A Biography for Young Americans)," 1932; "The Dragon's Teeth (A Study of War and Peace)," 1932; "Generalship, Its Diseases and Their Cure," 1933; "Grant and Lee (A Study in Personality and Generalship)," 1933; "Empire Unity and Defence," 1934; "The Army in My Time," 1935; "The First of the League Wars," 1936; "Memoirs of an Unconventional Soldier," 1937; "The Last of the Gentlemen's Wars," 1937; "Towards Armageddon," 1937; "The Decisive Battles," 1939; "Decisive Battles of the U. S. A.," 1942; "Machine Warfare," 1942; "Armored Warfare," 1943. Special correspondent, London *Daily Mail*, Italo-Abyssinian War. Major General, British Army, Retired. C. B., C. B. E., D. S. O.

[1] Reference notes are published in full on page 475.

The right of ransom was recognized by law. Not only did it diminish the ferocity of war, but it grew into a veritable trade, until in fifteenth-century Italy the hope of gaining ransom all but reduced fighting to a farce.

These various restrictions, as well as the economic conditions of the period, limited the ravages of war. So much so that, in the present age of unlimited destruction, the ordinances of Henry V of England[4]—not exactly a mild warrior—would sound foreign to our ears.

The ennoblement of war carried with it two further restrictions. The first, as only men of wealth and position could afford armor, placed war on an aristocratic footing. In turn the wearing of armor led to infighting and in consequence to the restriction of outfighting (missile warfare). Thus casualties were vastly reduced. Many of the battles of this period were no more than shock skirmishes between small bodies of armored knights in which individual combats were sought to prove rather the worth of the fighter than his destructive capabilities. The object was to unhorse one's opponent rather than to slay him. In short, battles were frequently little more than sharp-weapon tourneys.

The second was an attempt on the part of the Church to limit the use of missile weapons which were likely to proletarianize war, such as the arbalest or crossbow. Though the origins of this weapon are unknown, it would appear to have come into use at the beginning of the eleventh century. It was the most deadly missile thrower before the introduction of the long bow. In 1139 the Second Lateran Council forbade its use—except against infidels—under penalty of anathema "as a weapon hateful to God and unfit for Christians." The employment of foreign crossbowmen was also prohibited by Magna Carta.[5] As a weapon of war it was much admired by Richard I (Cœur de Lion), and when he went on his Crusade to Palestine he took a thousand crossbowmen with him.[6] Yet, in spite of anathema, its adoption was fairly general, except in England.[7]

IT is essential to bear these restrictions in mind when considering the warcraft of this period, for though, as Oman points out, the accession of Charles the Great in 768 marks the birth of a new epoch in the art of war,[8] that epoch was essentially a romantic one. "The hero of the imagination of Europe," as Lecky writes, "was no longer a hermit but a king, a warrior, a knight . . ." The age of the ascetic and of martyrdom was fast withering, and the age of the crusader and of chivalry was blossoming forth.[9]

This romanticism was thrilled into life by the conquests of Charles, who, to consolidate his empire, began to give shape to such elements of feudalism as already existed[10] and which, during his reign and the succeeding century, were further bound together by the incursions of the Vikings and Magyars.

To hold his vast empire, which stretched from the Elbe to the Pyrenees and from the English Channel to south of Rome, Charles made a systematic use of fortified posts. Each district was, so to say, picketed by a number of palisaded "burgs" which could be used as pivots of maneuver by his mobile forces. In turn, these forces were placed on a quality rather than a quantity footing. In the main they consisted of armored cavalry, and consequently the poorer classes were relieved from the burden of war. Such foot soldiers as Charles raised were not, as had hitherto been the case, a rabble carrying clubs and agricultural implements, but instead a force well equipped with sword, spear, and bow. Further, each count was compelled to provide his horsemen with shield, lance, sword, dagger, and bow.

Realizing that no army could really be mobile so long as it relied on foraging and was unable to storm walled cities and fortified posts, Charles organized two separate trains, one for siege and the other for supply, the latter carrying rations for three months and clothing for six. It is of interest to note that each was provided with bundles of iron-shod stakes as a protection against cavalry attack.

IT was, however, to armor that Charles paid the greatest attention. Not only did he establish a census of the armor in his realm, so that none should be hoarded,[11] but by law he prohibited its export. The importance he placed on armor may be gauged from the somewhat dramatized picture of his army left to us by Monachus Sangallensis:[12]

"Then appeared the iron king, crowned with his iron helm, with sleeves of iron mail on his arms, his broad breast protected by an iron byrnie, an iron lance in his left hand, his right free to grasp his unconquered sword. His thighs were guarded with iron mail, though other men are wont to leave them unprotected that they may spring the more lightly on their steeds. And his legs, like those of his host, were protected by iron greaves. His shield was of plain iron, without device or color. And round him and before him and behind him rode all his men, as nearly like him as they could fashion themselves; so iron filled the fields and the ways, and the sun's rays were in every quarter reflected from iron. 'Iron, iron everywhere,' cried in their dismay the terrified citizens of Pavia."

The first Viking raids occurred soon after Charles ascended the Frankish throne, but it was not until after his death, in 814, that they gradually grew more formidable. In 850 the whole manhood of Scandinavia took to the sea, and the half century which followed was one of the darkest periods in European history.[13]

These ferocious incursions vastly stimulated the military organization initiated by Charles. As the ill-armed local levies were useless, professional soldiers became essential. And as mounted men could alone keep pace with the raiders, more and more did military power pass into the hands of the nobility. Castles arose, strongholds were built, towns palisaded, and fortified bridges thrown over the rivers, either to block the path of the raiders or to form refuges for the peasantry.

Thus, out of these troubled times, to be followed by the Magyar incursions of the tenth century, emerged a completely militarized society based on the stockaded stronghold and the mounted knight, which, as time passed on, was modeled into the feudal order.

In England, other means were adopted by King Alfred (848-900). Though he also relied on fortifications, instead of raising cavalry he built a fleet and beat the Vikings in their own element. This led to the English continuing to rely on infantry, whereas on the Continent cavalry became the dominant arm.

OF these many raiders, the most pregnant in future events was that of Rolf, Rollo, or Rou. Of him we read in the Heimskringla Saga: "Gange-Rolf went afterward over sea to the west to the Hebrides, or Sudreyar (Sodor); and at last farther west to Valland (Brittany) where he plundered and subdued for himself a great earldom which he peopled with Northmen, from which that land is called Normandy."[14]

Little is known of his activities until 911. That year he took possession of Rouen and became vassal of Charles the Simple of France, as Duke of Normandy.

When we come to his three times great-grandson, William the Conqueror, and his victory over Harold of England at Hastings on October 14, 1066, there is presented to us one of the clearest examples of the influence of armament upon history. In this famous battle, which decided the destinies of England, two very different armies met. The English army was composed solely of infantry armed with sword, axe, club, and spear. The house-carls—Harold's bodyguard—wore helmets, byrnies, and carried kite-shaped shields. The axe was the dominant weapon. The Norman army consisted of three distinct bodies of men: knights who fought mounted, men at arms who fought on foot, and archers. The first and second were mail-clad and carried kite-shields; the three main weapons were lance, sword, and bow.

It would seem evident from the start that William recognized his armament superiority, for in his address to his troops he said: "Is it not shameful, then, that a people accustomed to be conquered, a people ignorant of the art of war, a people not even in possession of arrows, should make a show of being arrayed in order of battle against you?"[15]

From these weapons were developed two very different tactical formations. Harold's was that of the normal "shield-wall"—a hedge of shields: "Shield to shield, and shoulder to shoulder," as Æthelred I describes it at the battle of Ashdown in 871.

THIS is the third of a series of six articles on the development of weapons in the course of civilization being written by General Fuller, noted British soldier-author, for ARMY ORDNANCE. *The first article, "Armament and World History," appeared in the July-August 1944 issue and the second, "The Age of Valor," in the September-October number. In the present installment, General Fuller traces the course of armament from the time of the Crusades to the Battle of Crécy in 1346—a period "when knighthood was in flower" and the power of the feudal lords was implemented by armored horsemen and by the lance, pike, sword, and bow.*

By publishing the series at this time, ARMY ORDNANCE *hopes to emphasize for its readers the continuity of the armament problem, the importance of correct solutions to it, and the sheer necessity of well-informed public opinion if nations such as ours are to survive the periodic wars which, since the dawn of history, they have been compelled to meet.*—EDITOR.

William divided his army into three divisions—left, center, and right—each formed into three brigades, archers in front, then men at arms, and lastly mounted knights.

The battle opened at 9 A.M. and passed through four phases: (1) Under cover of a flight of arrows, William's knights charged the shield-wall and were repulsed. Other ineffective charges followed, and, William's left retiring in disorder, Harold advanced only to be driven back again. (2) A second general assault was delivered; yet the shield-wall held firm. (3) William next made a feint withdrawal, whereupon Harold again advanced, but to no purpose. Both sides were now exhausted. (4) As a further direct assault was not likely to succeed, William "commanded his bowmen not to aim their arrows directly at their enemy, but to shoot them in the air, that their cloud might spread darkness over the enemy's ranks."[16]

The effect was immediate and fearful, as Freeman writes: "Helmets were pierced; eyes were put out; men strove to guard their heads with their shields, and, in so doing, they were of course less able to wield their axes."[17] Thus, at length, was the shield-wall disarrayed; whereupon a crowd of horsemen burst through, and the battle was won.

From an armament point of view, the facts to note are these: Though good cavalry could not break good infantry, and good infantry could not attack good cavalry, when fire and shock were combined, infantry relying on weapons for close fighting were impotent. Further, had the archers been unsupported by the knights, they could easily have been driven off the field by Harold's infantry. Although it was little realized in the West at the time, except perhaps by William, the bow had proved itself to be the dominant weapon, as it long had been acknowledged in the East.

Why this was not grasped earlier and why, after William's victory, it took nearly three centuries before the English revolutionized tactics with the bow, and why even then Western chivalry failed to adopt it, can only be satisfactorily explained by the hypothesis that missile fighting was as abhorrent to Western military ideals as gas warfare is today. In the Eastern or Byzantine Empire no such antipathy existed. This may be clearly seen in Justinian's army commanded by Belisarius (505-565). That great general said: "I found that the chief difference between them [the Goths] and us was that our Roman horse and our Hunnish fœderati are all capital horse-bowmen, while the enemy has hardly any knowledge whatever of archery. For the Gothic knights use lance and sword alone, while their bowmen on foot are always drawn up to the rear under cover of the heavy squadrons. So their horsemen are no good till the battle comes to close quarters and can easily be shot down while standing in battle array before the moment of contact arrives. Their foot-archers, on the other hand, will never dare to advance against cavalry, and so keep too far back."[18]

THE Battle of Taginæ, won in 552 by the eunuch Narses over the Gothic king Baduila (Totila), is an exact forerunner of Crécy. Drawing up some 10,000 dismounted knights, Narses flanked them by two advanced wings of 4,000 archers, each in crescent formation, and in rear of the center he held in reserve a body of mounted knights. Baduila's army, advancing against the dismounted knights, was decimated by the archers and when exhausted was charged and routed by Narses' mounted reserve. "So ended in complete success," writes Oman, "the first experiment in the combination of pike and bow which modern history shows."[19]

Why, in spite of its internal rottenness, the Eastern Empire endured for a thousand years, whereas the kingdoms of Western Europe were in a state of anarchy, was due not to valor but to military organization. The wealth of the Empire, the incomparable strength of Constantinople as a fortress, and the codification of the art of war by the Emperors Maurice (562-602) and Leo the Wise (886-911) in their manuals the "Strategicon" and "Tactica" gave the armies of the Empire a stability utterly unknown in the West. War

Until recent times, Aryan peoples have generally preferred clean fighting to crooked in order to maintain the supremacy of the valiant. Thus, in the Code of Manu, VII, 90, we read: "The king shall not slay his enemies in battle with deceitful or barbed or poisoned weapons, nor with any having a blade made hot by fire, or tipped with burning materials." For a like reason the "insidious bow" was proscribed in the wars of the early Teutons.

was looked upon from a practical and not an heroic point of view. Battles were avoided rather than sought, and to sacrifice lives in attempting to achieve by valor what could be gained by cunning was considered the worst of bad generalship by the Byzantines.

The combatant forces of the Empire were divided into cavalry, infantry, and artillery. The first wore steel caps and mail shirts, carried circular shields, and were armed with bow, lance, sword, axe or mace. The infantry, organized in sections, companies, and battalions, were divided into heavy and light. Heavy infantrymen were clothed in mail and carried shield, lance, sword or axe. The light infantry consisted entirely of archers equipped with a bow, a quiver of forty arrows, and an axe. The artillerymen worked the mangonels—a generic name for any engine which projected stones, arrows, or fireballs. There were three distinct types—the catapult, balista, and trebuchet.[20]

BESIDES these weapons, the Byzantines possessed one which was unique and which Colonel Hime rightly calls "the palladium of the Empire."[21] It was "sea fire," also called "Greek fire"—an inflammable mixture which ignited on contact with water. According to the Chronography of Theophanes,[22] written between 811-815, in 673 an architect by the name of Kallinikos fled from Syria to Constantinople and there compounded a "sea fire" which enabled the Byzantines to destroy the Moslem fleet during the first siege of that city. Its composition is unknown, but apparently it was an oleaginous substance discharged by means of a siphon, which Hime clearly proves was "a fire engine, or water engine, or squirt."[23] These engines were known as early as the first century A.D. and are described by Heron of Alexandria.[24] Hime writes: "The lump of inflammable matter was projected, and at the same time ignited, by applying the hose of a water engine to the breech of the tube [wood lined with copper] which thus became an integral part of the apparatus . . ."[25]

According to the Alexiad:[26] "In the bow of each ship he (the Admiral) put the heads of lions and other land animals, made of brass and iron, gilt, so as to be (quite) frightful to look at; and he arranged that from their mouths, which were (wide) open, should issue the fire to be delivered by the soldiers by means of (or through) the 'flexible' apparatus."[27]

At close quarters in a sea fight the effect of this fire was deadly, as it was impossible to extinguish it. Therefore, as a projectile, sea fire may be classed among the few master weapons known. In the second siege of Constantinople (717-718) it proved catastrophic to the Moslem fleet, and in 941 and 1043 two Russian fleets were destroyed by it. It is not to be confounded with "wild fire," various mixtures of sulphur, naphtha, pitch, petroleum, etc.,[28] which for ages had been known throughout the East. Hime points out that the only passage he can recall among the old writers in which the two fires are discriminated and correctly named occurs in the metrical romance "Richard Cœur de Lion," about the time of Edward I (1272-1307).[29]

Wild fire, frequently called "Greek fire," was used by Edward I in 1304 during the siege of Stirling Castle and on many subsequent occasions.[30] Today it is represented by the flame projector or *Flammenwerfer*.[31] As regards sea fire, its composition was kept so close a secret that, after the conquest of Constantinople by the Crusaders in 1204, it would seem to have been lost. Probably they were too ignorant and disdainful to show interest in such low cunning.

The first decisive disaster suffered by the Byzantine Empire was at Manzikert in 1071, a defeat due almost entirely to the Emperor Romanus Diogenes neglecting to follow the tactics of Maurice and Leo. So catastrophic were the results of this battle that, in order to secure Europe against a Seljuk invasion, in 1095 Pope Urban II called Christendom to arms and proclaimed the First Crusade. The war he preached was far more than a military adventure; for men of good faith were offered alliance with the supernatural, remission of their sins, and life eternal under the invincible banner of their General—Jesus. In intent it was the apotheosis of chivalry.

As in all ideological wars, strategy was smothered by propaganda. Destruction rather than victory was its aim.[32] In it, as through a fog, the weaknesses in the feudal system were exaggerated. Though there were innumerable leaders, there was no single chief. Though in the armies of this period infantry had lost all tactical worth, tens of thousands of foot soldiers followed the knights, not to form line of battle, but to save their souls; for poor and rich were, spiritually, equal.

At the Battle of Dorylæum (1097), the first of any size fought, the impetuosity of the knights, not forgetting a stroke of good luck, won through at heavy cost—so much so that in the following year, at the Battle of Antioch, they began to change their tactics. The infantry were divided into companies under competent leaders and in part, at least, armed with bow and crossbow. These companies were deployed into line in front of the knights, a distribution which proved so successful that both sides were filled with wonder, the Moslems attributing their defeat to the inscrutable will of Allah, and the Christians their victory to the Holy Lance which had been borne before them.

Nevertheless, little by little, it dawned upon the Crusaders that when they combined mailed cavalry with organized bodies of foot archers and fought on ground which was unfavorable to their enemy's Parthian tactics, they generally won and that when they did not, they lost. As Professor Oman comments: "The one all-important canon which had to be observed was that there must be infantry on the field to serve as a support and rallying point for the cavalry. If the foot-soldiery seldom won the battle, they always made the winning of it by the knights possible."[33]

OF all the Christian leaders, Richard Cœur de Lion showed the highest tactical acumen. In 1192, having raised the siege of Acre, he lay encamped near that town, when, on August 5th, he learnt that 7,000 Mamelukes were rapidly advancing on him. Though he had but 55 knights and 2,000 infantry, mainly crossbowmen, he deployed them as follows: In front, a line of infantry spearmen kneeling. Immediately in rear, a line of crossbowmen covering the intervals between the spearmen and behind each crossbowman a crossbow loader, so that fire might be continuous. This combination of pike and bolt not only kept the Mamelukes at bay, but killed 700 of them and 1,500 of their horses. When at length they broke

back, Richard, at the head of no more than fifteen knights, hewed his way through his demoralized enemy, and then cut his way back again. In this astonishing battle his losses were two men.

Strange to say, field tactics of this excellence were completely lost on Western Europe. There, militarily, little was learnt from the Crusades. Though they called forth the heroic and for 150 years inspired Western Europe with a unity it has never since known, and has never quite forgotten, as far as the arts of field warfare and armament are concerned, they might never have been fought. The two main reasons were that war had been monopolized by the nobility and that military thought was defensive. Only contests between nobles ranked as war; consequently, thought was concentrated on improving armor and building castles.

Toward the end of the twelfth century, plate armor was introduced, which, until the armorer's art was sufficiently advanced, led to the wearing of double armor; that is, plate over mail. Together they became so heavy that, at the Battle of Tagliacozza in 1268, Charles of Anjou's knights rolled the exhausted Ghibellines out of their saddles by seizing hold of their shoulders. In the fourteenth century, plate armor reached its full development and double armor was virtually abandoned. As plate armor made the long kite-shield less necessary, its size was considerably reduced.

As the weight of armor increased, until the barded warhorse had to carry between 350 and 400 pounds, when ground was unsuitable for charging or their horses exhausted, knights took to fighting on foot—not as infantry, but as dismounted cavalry, because their armor impeded the free movement true infantry require in order to wield their arms. Tenchebrai (1106), Bremûle (1119), the Battle of the Standard (1138), and Lincoln (1146) were all dismounted cavalry contests. In the first—fought between Henry I of England and his brother Robert—whereas Robert dismounted all his knights, Henry kept a small mounted force in hand. This body decided the battle, and so well were men armored that not a single knight on Henry's side was slain. At Bremûle, Henry dismounted 400 of his 500 knights, whereas Louis VI of France dismounted none and was beaten. Again, the battle was all but a bloodless one: 140 French knights were captured and only 3 killed. As Oderic said: "For they were clothed from head to foot in mail, and because of the fear of God and the fact that they were known to each other as old comrades, there was no slaughter."[34]

While the English and the Flemings never quite abandoned the infantry idea, amongst other peoples battles between dismounted knights were exceptional. Most encounters were clashes between horse and horse, in which infantry took little or no part and frequently were altogether absent. Nevertheless, on account of the increasing wealth of the towns, due in no small measure to the loans raised by them to finance the Crusades, we find, first, a steady increase in mercenaries, and, secondly, the appearance of well-equipped city militias.

Mercenaries, who had for long existed, seem to have been considerably increased after the introduction of the crossbow, for simultaneously with its advent came into use the term *solidarii* (soldiers)—hired fighters. Thence onward the mercenary bands grew in importance and became essential in all other than purely local wars. In the thirteenth century they evolved into the condottiere system, which was the very opposite of the feudal because it relied on professional soldiers who sold their services to the highest bidder and therefore served no permanent master, nor were they bound by any code of honor.

Why, in spite of its internal rottenness, the Eastern Empire endured for a thousand years, whereas the kingdoms of Western Europe were in a state of anarchy, was due not to valor but to military organization. The wealth of the Empire, the incomparable strength of Constantinople as a fortress, and the codification of the art of war by the Emperors Maurice and Leo the Wise gave the armies of the Empire a stability utterly unknown in the West.

Militias are mainly connected with the Netherlands, which, never having been conquered, had throughout maintained considerable infantry forces alongside the feudal cavalry. In the twelfth century, these militias, generally called Brabançons, were armed with pike, mail skirt, and steel cap; later on, the pike was replaced by the crossbow. Thousands of Brabançons were present at the Battle of Bouvines in 1214; but they did not distinguish themselves greatly until Courtrai, in 1302. There they won the day, utterly routing the French under Robert of Artois. As Villani wrote, it was something new and marvelous for a feudal army of 50,000 men, including 7,500 cavalry and 10,000 crossbowmen, to be beaten by 20,000 burghers.[35] However, the tide in favor of infantry had not yet turned. Two years later a much larger army of Flemish burghers was no match for the well-handled feudal army at Mons-en-Pevèle; again this was confirmed at Cassel in 1328, and at Roosebeke in 1382.

THOUGH without armor there could have been no feudal overlord—for not only did it give its wearer personal security but it differentiated him from all unarmored men—without the castle there could have been no feudal system, for it was the castle which gave permanence to the knightly caste. This was the greatest military contribution of the Crusades. They put Western chivalry in touch with the superb castles and fortified cities of the Eastern Empire. There, the most perfect example was Constantinople itself, a city surrounded by a single seawall nine miles in length and a triple wall on its landward side. This wall had been built by Theodosius II in the fifth century. It was four miles long, and the inner wall was forty feet high and provided with a hundred and twelve 60-foot towers.

One of the most renowned of the crusading castle builders was Richard Cœur de Lion; his masterpiece was Château Gaillard. In Palestine many of the Crusaders' castles were of enormous strength, notably Kerak-in-Moab and Krak des Chevaliers. These strongholds, if adequately garrisoned, were impregnable except by means of starvation or through treachery.

Though in the eleventh century, castles of masonry were both few and crude, in the fourteenth they dominated every district and county. As Oman points out: "The methods of attack made no corresponding advance, and by 1300 the defensive obtained an almost complete mastery over the offensive, so that famine was the only certain weapon in siegecraft."[36]

The effect of this was the infrequency of great battles and the frequency of sieges, the weaker side finding it more profitable to seek shelter than to take the field. As the knights would not dig, hew, mine, and batter, infantry became essential in the form of pioneers as well as of castle garrisons. Further, it was the defense and attack of castles more so than

field battles which encouraged the growth of the crossbow. Siege engines, however, remained much as they had been, with the single exception of the trebuchet, an engine supposed to have been introduced during the twelfth century. Its "projectile force . . . was obtained from the gravitation of a heavy weight, and not from twisted cordage as in the catapult and balista. . . . Provided the engine was of sufficient strength and could be manipulated, there was scarcely any limit to its power."[37] We read of a machine which cast a stone projectile weighing twelve hundredweights.[38]

As the castle was the mainstay of the Crusaders against the Moslems, so, as I have mentioned, it was also the mainstay of the feudal system. On account of the primitive commissariat of field armies in those days, which limited the duration of their campaigns, a people could not be conquered as long as their castles and walled cities held out. Further, as a hundred reliable men could hold a strong castle against thousands, the castle dominated war.

For a full century and a half before the bombards of Mohammed II thundered against the walls of Constantinople, missile power in the form of the English longbow was preparing the way, for by placing a dominant weapon in the hands of the common soldier, psychologically as well as tactically it heralded the downfall of feudalism.

The results were not only the long survival of the Eastern Empire and of many of the smaller states, but also the prolonged resistance feudalism put up against centralized authority. As in classical Greece civilization was built around the city state, in feudal Europe it was built around the castle until the introduction of the cannon. Nevertheless, for a full century and a half before the bombards of Mohammed II thundered against the walls of Constantinople, missile power in the form of the English longbow was preparing the way, for by placing a dominant weapon in the hands of the common soldier, psychologically as well as tactically it heralded the downfall of feudalism.

THIS weapon was of elm, six feet in length, from which a 3-foot arrow was propelled. It was a far more powerful weapon than the short Norman bow.[39] It was adopted from the South Welsh by Edward I (1272-1307), who in his wars in Wales had learnt its value when combined with armored cavalry.

In 1298, at Falkirk, he put this weapon to the test against the Scots under Wallace. Wallace drew up his spearmen in four schiltrons or phalanxes, with archers on either flank and a reserve of 1,000 cavalry in rear. Edward formed his army into three battles—right, left, and main—the third under his own command. The right and left battles charged the Scots and dispersed their archers; nevertheless the schiltrons held firm. Edward then brought up his bowmen and ordered them to concentrate their arrows on selected points in the enemy's front. This they did with terrific effect. Thereupon Edward charged at the breaches in the Scottish line, and a general massacre followed.

Strange to say, in 1314, though Edward II (1307-1327) had 30,000 bowmen at Bannochburn, he placed them behind his cavalry and made such poor use of them that he was decisively defeated. Thus the lesson of the longbow had to be relearnt, as it was, in 1332, at Dupplin Muir. This battle—one of the most astonishing in medieval warfare—was fought between the "Disinherited"—Edward Baliol, Henry of Beaumont, and others—and Donald Earl of Mar, the Scottish regent. The former had 500 knights and men at arms and between 1,000 and 2,000 archers. The latter commanded 2,000 men at arms and 20,000 foot. Fully aware of the desperate odds against them, the "Disinherited" first attacked Mar by night. But when dawn broke and they discovered their enemy advancing in battle array, they took up position on the slope of a hill. Dismounting all but forty of their cavalry, they formed them up in phalangial order, with archers thrown forward on their flanks. Thus their order of battle assumed a crescent formation. Paying no attention to the archers, Mar charged down on Baliol's center and drove it in. Thereupon the flanking archers wheeled inward, and opened so devastating a fire that the Scots were driven into a confused mass and all but exterminated. At once Henry of Beaumont and some of his followers mounted their horses and chased the fugitives off the field.

In 1333, Edward III (1327-1377) may be said to have patented these tactics at the Battle of Halidon Hill; for thence onward for a hundred years they remained the English sealed pattern; the most notable example of which is the Battle of Crécy, fought on August 26, 1346.

The two armies which faced each other on this famous field were very different both in armament and outlook. The French, under Philip of Valois, was purely feudal; the English, under Edward III, seminational.[40] The one not only despised infantry, but regarded their appearance on the field as an insult. The other was largely composed of infantry. To the French, to be differently armed was unchivalrous,[41] nor was it knightly to rely on missiles as decisive weapons.

The French army consisted of 12,000 men at arms, of whom two-thirds were *gentile gens*,[42] and some 50,000 foot, including 6,000 Genoese crossbowmen. The English force comprised 3,900 men at arms, of whom a quarter were knights, 11,000 archers, and some 5,000 Welsh infantry. Many of the archers were mounted.[43]

Edward divided his army into the customary three battles, two forward and one in rear. In the interval between the forward he drew up a wedge of archers, its apex facing the French, and on the outer flank of the two battles he posted wings of archers as at Dupplin.

The attack was opened by an advance of the Genoese, who, outranged and decimated by the English arrows, broke back. Thereupon the French knights, suspecting treason, cut their way through them and charged, to be decimated in turn. Their reckless charges were repeated again and again until the battle ended in a catastrophic defeat for Philip. Of Philip's army, 1,542 lords and knights fell and an unknown number of foot. Edward lost two knights, one squire, forty men at arms and archers, and a few dozen Welsh.

From now onward feudalism rapidly lost ground, not only because the bow had become the dominant weapon, but because the idea to which it gave expression was the need of a professional, national army. Already during the previous two centuries the national armed gatherings of the Albigenses had for long proved invincible, as later did the Hussite armies in the fifteenth century. Foremost in this democratization of war were the Swiss, for their peasant armies of halberdiers and pikemen taught the Austrian knights a lesson equal to the bow. At Morgarten (1315), at Laupen (1339), and at Sempach (1386) the Swiss were invincible, and, as

Colonel Lloyd remarks: "After this achievement . . . it was idle to say that the wearing of armor and the use of weapons was reserved by God and nature for persons of quality."[44]

The growth of national militias and the corruption of the condotierre system as much as the pike and the longbow brought the Age of Chivalry to a close. Feudalism had not only outgrown its usefulness but also its ideals. Beaten as the armored knight now was in the field, all that was lacking to accomplish his final doom was a weapon which would batter down his castle. Thus we pass to the Age of Gunpowder and its weapons of cunning. (*To be continued.*)

REFERENCES

[1] "History of European Morals," William Edward Hartpole Lecky (1902), Vol. II, p. 95. [2] *Ibid.*, Vol. II, pp. 259-260. [3] Encyclopædia Britannica (Eleventh Edition), Vol. 27, p. 321. [4] "Agincourt," H. Nicolas (1833), Appendix 31. [5] Magna Carta, Clause LI. The word used is "balistarios." [6] "The British Army," Sir Sibbald Scott (1868-1880), Vol. II, p. 78. The standard work on this weapon is "The Crossbow, Medieval and Modern, Military and Sporting," Sir Ralph Payne-Gallewey, Bt. It is of interest to note that the crossbow "was considerably used by the Chinese in the China-Japan war of 1894-1895" ("The Art of Attack," H. S. Cowper, 1906, p. 266). [7] New inventions have always shocked the conventionally religious mind. As Spengler says, "Ever and ever again, true belief regarded the machine as of the devil" ("The Decline of the West," Vol. II, p. 502). Until recent times Aryan peoples have generally preferred clean fighting to crooked in order to maintain the supremacy of the valiant. Thus, in the Code of Manu, VII, 90, we read: "The king shall not slay his enemies in battle with deceitful or barbed or poisoned weapons, nor with any having a blade made hot by fire, or tipped with burning materials." For a like reason the "insidious bow" was proscribed in the wars of the early Teutons whose valor was outstanding. [8] "A History of the Art of War," Charles Oman (1898), p. 75. [9] "History of European Morals," Vol. II, p. 272. [10] The germ of feudalism is to be seen in Tacitus' description of the German tribes: "In the field of battle, it is disgraceful for the chief to be surpassed in valor; it is disgraceful for the companions not to equal their chief. . . . To aid and protect him, to place their own gallant actions to the account of his glory, is their first and most sacred engagement. The chiefs fight for victory, the companions for their chief. . . . The companion required from the liberality of his chief the warlike steed, the bloody and conquering spear; and in place of pay, he expects to be supplied with a table, homely indeed, but plentiful" ("Germania," Bohn's edition 1854, section 14). A note on the above reads: "Hence Montesquieu ("Spirit of Laws," XXX, 3) justly derives the origin of vassalage. At first, the prince gave to his nobles arms and provision. As avarice advanced, money, and then lands, were required, which from benefices became at length hereditary possessions and were called fiefs. Hence the establishment of the feudal system." [11] See Oman, p. 80. [12] *Id.*, p. 86. [13] See "Heimskringla, the Norse King Sagas," Snorre Sturlason (Everyman's Library), Chap. III, p. 64. [14] *Ibid.*, p. 68. Valler or inhabitants of Wales and Cornwales (Cornwall), Welsh is the same as Valskr.

[15] The Chronicle of Henry of Huntington, p. 211 (Bohn's edition, p. 211). It is strange that the English never took to the bow. Most naval peoples used it—the Athenians, Vikings, Venetians, and Genoese. [16] *Ibid.*, p. 212. [17] "The Norman Conquest," Edward A. Freeman, Vol. III, p. 497. [18] Procopius, "The Gothic Wars," I, 27 (Loeb's edition, Vol. III, p. 261). [19] Oman, p. 35. [20] For a full description of the organization and tactics of the Byzantine army, see Oman's "History of the Art of War," pp. 169-226; also, for a brief account, J. F. C. Fuller's "Decisive Battles," Chap. IX. For a description of these engines, see "The Projectile-Throwing Engines of the Ancients," Sir Ralph Payne-Gallewey (1907). Also, "Mathematici Veteres," Thévenot (1693). [21] "The Origin of Artillery," Lieut. Col. Henry W. L. Hime (1915), p. 44. [22] *Ibid.*, p. 27. [23] *Ibid.*, p. 37. [24] See "Mathematici Veteres," Thévenot, p. 180. [25] Hime, p. 38. [26] "A Byzantine History," written by Anna Comnena, covering the years 1081-1118. [27] Quoted by Hime, p. 39. [28] *Ibid.*, Table II, p. 28. [29] *Ibid.*, p. 40. [30] *Ibid.*, pp. 41-42. [31] "Dans une expérience faite au Havre, 1758, avec une pompe à huile de naphte, dont le jet était enflammé par une mèche allumée, on brûla même une chaloupe" (Berthelot, *Revue des Deux Mondes*, August 15, 1891, p. 800). At the siege of Charleston, 1863, not only was solidified Greek fire in tin tubes employed (History of the War of Rebellion, Ser. 1, Vol. XXVIII, pt. 1, p. 33) but coal naphtha placed in shells or pumped through a hose. Suggestions for its use were again made in 1870 (Hime, pp. 39-40). [32] Quincy Wright points out: "But when war is for an idea . . . the necessary limits to destructiveness have not been evident. If one fights for democracy, it may be appropriate to destroy all the states and most of the individuals so that a clear field will remain in which democracy can grow. If it is Christianity against Islam, each may be prepared to destroy all the adversaries if only a few of its side can remain to perpetuate the true faith" ("A Study of War," Vol. I, p. 160). [33] Oman, p. 294. At the Horns of Hattin, in 1187, they failed to do so and suffered their most decisive defeat. For this battle, see J. F. C. Fuller's "Decisive Battles," Chap. X. [34] Oman, p. 384.

[35] See "A Review of the History of Infantry," Col. E. M. Lloyd (1908), p. 53. [36] Oman, p. 356. [37] "The Projectile-Throwing Engines of the Ancients," Sir Ralph Payne-Gallewey, pp. 27-28. [38] "These siege engines throw other missiles besides stones and javelins. They throw millstones, flaming projectiles, putrid corpses, and live men. A dead horse in the last stage of decomposition bundled up and shot by a trebuchet into a town of which the defenders were half dead with starvation, started a pestilence. [39] As a national sport, archery was encouraged in England after the conquest. In 1252, according to Henry III's Assize of Arms, all forty-shillings freeholders were required to posses a bow and arrows. The longbow arrow penetrated two layers of mail. In a trial made before Edward VI in 1550, arrows were shot through a one-inch board of well-seasoned timber ("Archery," Badminton Library, C. J. Longman and others, 1894, p. 431). [40] By 1350, feudalism in England was practically extinct, as the king had ceased to summon the feudal host. [41] "In olden times he received great praise and honor who let his enemy have equal arms. Challenges went out in good order to those who were good knightly people. Now no one is a good captain who cannot beat his handicapped enemy. Now he is praised and extolled in war who is able and knows how to cheat his enemy" (Max Jahns, "Geschichte der Kriegswissenchaften," 1889, p. 335. Quoted by Vagts in "A History of Militarism," 1938, p. 43). [42] *Chandos Herald* (1883), p. 310. [43] *English Historical Review*, Vol. XIV, p. 767. [44] "A Review of the History of Infantry," p. 82.

Election of Officers

Association Leaders Are Chosen in Biennial Balloting

AS a result of the biennial election of officers and directors of the Army Ordnance Association, the following members were elected for terms of office beginning January 1, 1945: *President* (to serve two years): Benedict Crowell, Cleveland, Ohio; *Vice-Presidents* (to serve two years): William W. Coleman, Milwaukee, Wis., and Frederick H. Payne, Greenfield, Mass.; *Directors* (to serve four years): John D. Biggers, Toledo, Ohio; Robert P. Lamont, New York, N. Y.; Frank A. Scott, Cleveland, Ohio; James W. Wadsworth, Geneseo, N. Y.; James L. Walsh, New York, N. Y.; (to serve two years): K. T. Keller, Detroit, Mich., and Chas. E. Wilson, New York, N. Y.

General Crowell, Special Consultant to the Secretary of War, is president of the Central National Bank of Cleveland. He served as Assistant Secretary of War and Director of Munitions in World War I. A graduate of Yale University, he is by profession a mining engineer. With Mr. Wadsworth he collaborated in framing the National Defense Act of 1920. He is a brigadier general in the Officers' Reserve Corps, U. S. Army.

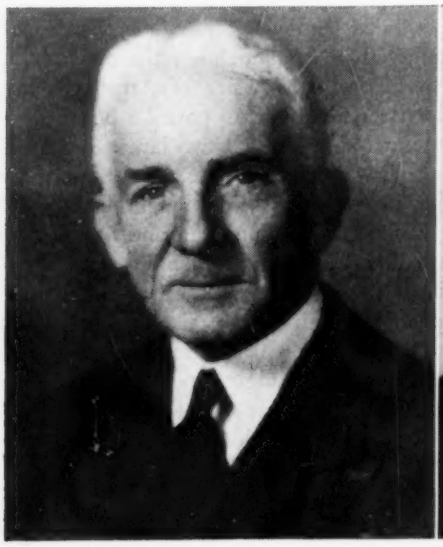
BRIG. GEN. BENEDICT CROWELL

Colonel Coleman is president of the Milwaukee Post, Army Ordnance Association, and chairman of the Bucyrus-Erie Company, South Milwaukee. He served as a special assistant to the Chief of Ordnance for artillery production in the first World War. He is a graduate of Lehigh University and has been an active proponent of industrial preparedness during the past two decades. In World War II he assisted in a very noteworthy manner in the design and the production of heavy artillery. He is chairman of the Coleman Board of the Association for the study and planning of postwar preparedness. He served as a colonel of Ordnance in World War I.

Colonel Payne is assistant chief of the Springfield Ordnance District and former president, Greenfield Tap and Die Company, Greenfield, Mass. He served as Assistant Secretary of War in the cabinet of President Hoover and has long been identified with industrial-preparedness activities. First as a financial expert in the field of banking and later as an official of several industrial organizations, he is closely connected with American industry. He is a colonel in the Officers' Reserve Corps.

Mr. Biggers, president of Libbey-Owens-Ford Glass Company, is former director of production, Office of Production Management. He also served as Minister to Great Britain in charge of production coördination. A graduate of the University of Michigan, he was Administrator of Census of Unemployed in the United States, 1937-1938. Since his service in the Office of Production Management, he has devoted much of his time and ability to the cause of industrial mobilization for the defeat of the Axis forces in this war.

Mr. Keller is president of Chrysler Corporation. Long a leading figure in the automotive industry in the United States, Mr. Keller typifies the phenomenal record of that industry in the production of ordnance in this war. He is a member of the Advisory Staff of the Chief of Ordnance and a director of the Detroit Post, Army Ordnance Association. He is a member of the American Society of Mechanical Engineers and the Society of Automotive Engineers.



COL. WILLIAM W. COLEMAN

COL. JAMES L. WALSH

COL. FREDERICK H. PAYNE

COL. ROBERT P. LAMONT

MR. JOHN D. BIGGERS

COL. FRANK A. SCOTT

Colonel Lamont is former Secretary of Commerce and president of American Steel Foundries. He served as chief of the Procurement Division of the Ordnance Department in World War I. A graduate of the University of Michigan, he was long identified with the steel industry as an official of various steel companies. He is a former president of the American Iron and Steel Institute and was formerly a colonel in the Officers' Reserve Corps.

Colonel Scott was first chairman of the General Munitions Board and of the War Industries Board. He organized and brought to successful fruition the transition of American industry for war production in World War I. Formerly an official of the Warner & Swasey Company, Cleveland, he is acknowledged to be one of the foremost students of military affairs in the United States. He is an Army Ordnance Medalist (1932) and former chief of the Cleveland Ordnance District. He was a colonel in the Officers' Reserve Corps.

Mr. Wadsworth, member of Congress from the 39th New York District, is the foremost authority on military affairs in the Congress of the United States. As a member of the United States Senate (1915-1927) he led the forces of mobilization in World War I. He has directed many of the legislative enactments for industrial mobilization in World War II and is a member of the Special Committee on Postwar Military Organization.

Colonel Walsh is chairman of the Committee for War Production, American Society of Mechanical Engineers. He is known throughout the United States as an exponent of industrial preparedness. A graduate of the United States Military Academy, class of 1909, he served as an assistant to Maj. Gen. William Crozier and Maj. Gen. C. C. Williams, Chiefs of Ordnance, United States Army, World War I. In 1920 he founded and was first editor of ARMY ORDNANCE magazine. He was awarded the Crozier Medal in 1940.

Mr. Wilson is president of the General Electric Company and former vice-chairman of the War Production Board. He has spent his entire business career with the General Electric Company and is an outstanding leader of American industry in peace and in war. His services to the War Production Board, to the fighting services, and to industry in war are well known. In January 1944 he presented to the Army Ordnance Association a plan for postwar military and armament preparedness, research, and development which has met with the general approval of the country at large.

MR. K. T. KELLER

MR. CHAS. E. WILSON

MR. JAMES W. WADSWORTH

Metallurgical Warfare

The Production of High-Quality Steel for Ordnance Matériel

Lieut. Col. G. L. Cox

When the Axis forces decided to make World War II a war of metals they moved "right down our alley." America's capacity for the mass production of steel and American ingenuity in devising new alloys to meet critical shortages have resulted in a flood of superb arms and armor that is sweeping the enemy back to the yawning brink of complete and final defeat.

WE entered World War II with a full realization of the tremendous metallurgical job ahead of us. Our enemies had already shown us this was going to be a war of metals. Perhaps little did Herr Hitler realize that when he chose to make this a war of metals he moved right into our alley and started fighting our kind of war. That made his eventual defeat inevitable. We do not underestimate our enemy's technical ability, but we do admit with humble pride our own capabilities and resourcefulness. We are particularly zealous of our ability to mass produce efficient fighting equipment. One has only to view the Normandy and Brittany campaigns to see the tremendous power in the integration of efficient matériel, mass production, and military genius.

That the steel maker has played a vital part in this integration is now a matter of record, and, on the whole, the steel makers have done a magnificent job for which the Ordnance Department is justly proud. Naturally, all have had their "growing pains," and some "ups and downs," but they were expected and allowed for. Schedules have been met, and the tremendous expansion has gone ahead without a serious setback to standards of production.

That the Ordnance Department was on the job to lend its share to this integration is emphasized by the fact that as early as 1923 it formed an advisory board composed of leading metallurgists and service representatives, later to be known as the Ferrous Metallurgical Advisory Board (see ARMY ORDNANCE, May-June 1941, Vol. XXI, No. 126, p. 607), to advise on matters concerning the coördination of Ordnance requirements with steel-making processes and practices. In 1939-1940 the activities of this board were greatly extended with the formation of subcommittees whose interest related to specific phases of ordnance such as guns, armor, and welding of armor, and whose membership included producers and users, both American and allied, of the products concerned. Through the medium of these subcommittees, technical problems were discussed, solved, and the information disseminated to the benefit of the entire steel-making industry.

The growth of the steel industry in this country was enormous in the years 1939 to 1942. Much of this increase was due to orders placed by our allies in this great war. After Pearl Harbor, domestic war orders gave a tremendous impetus to the production curve, until the programs of all services began to level off. From now until the end, the curve will probably continue with normal expected ups and downs.

We in Ordnance are frequently asked how U. S. steel production compares with that of other countries and also how our matériel compares with our enemies'. That our steel-production record has been outstanding among the nations of the world is emphasized by the fact that our steel industry was producing for countries now our allies long before it "took up arms" in active defense of America. The wisdom of that is self-evident. Likewise, the tremendous factor American armament has played in the war thus far is common knowledge. Marshal Stalin said at the Teheran conference: "Without American production we would not be able to win the war." Our allied troops repeatedly praise American ordnance made from American steel. The fact that this country is known as the "Arsenal of Democracy" seems proof enough that allied fighting weapons, made from American steel, are second to none.

The fighting strength of the modern army can be measured in terms of tons of metal produced from the furnaces. Concurrent with the emphasis on metals from a tonnage viewpoint there is an equal trend toward greater and greater demands on the performance of these metals. War is movement and change. Matériel considered superior in the last war is wholly inadequate today, and today's "secret weapon" may be obsolete tomorrow. In guns the trend is to higher and higher velocities, longer range, and greater striking power, and the carriages holding the guns must be mobile, with overland speed comparable to that of our automobiles.

IN tanks the armor must be good enough to stop the heavy high-velocity projectiles of modern antitank guns—stopping bullets is not enough. Armor must be tough as well as hard. Mass production has emphasized the use of welding, and the metal must be weldable with no loss in significant properties. What do these requirements mean? They mean metals have to be stronger, tougher, and amenable to fabrication methods of modern mass production. Mass production is essential because our enemies had quite a few years' start on us and we had to pass them, which was accomplished in record time.

Great mobility requires lightness in weight, so for our highly mobile, high-powered weapons we must drain every ounce from the steel of which they are made. We must keep factors of safety at such a level that the matériel will be safe in the hands of our troops but not so excessive that unneeded weight is carried around. In the bazooka, mortars, and automatic hand weapons, today's soldier carries (and literally on his back) firepower many times that of his predecessor. Larger-caliber cannon are going into planes, giving to the great mobility of the airplane the added factor of great firepower. The designer of these cannon must conserve every pound of steel, and yet of all applications of guns, this is the one that must be safe. A gun failure here may mean the loss of a valuable crew of highly trained officers and technicians to say nothing of a plane worth many times the cost of the gun.

Colonel Cox is chief of the Cannon Branch, Artillery Development Division, Office of the Chief of Ordnance.

Signal Corps

THIS CAPTURED JAPANESE MEDIUM TANK HAS ARMOR AND FIREPOWER VERY INFERIOR TO U. S. TANKS

The immense problem of supplying these items of ordnance is not all; there is the problem of availability of raw materials and the alloying elements to give the steel the required properties. Well remembered is the day in early 1942 when industry and Ordnance were told there was not enough steel, aluminum, nickel, chromium, vanadium, molybdenum, and numerous other metals to go around. Somebody had to give up part of his alloys. It was like "robbing Peter to pay Paul." The restriction went all the way back to the melter. He had to learn to make new alloys containing lesser amounts of these critical alloying elements, and yet he was told there could be no sacrifice in quality or basic engineering properties. That was indeed a task. Through the joint effort of steel and Ordnance metallurgists the accomplishment was superb—the record speaks for itself. Heat-treating facilities were much too inadequate to handle the armor and gun programs. What was done? Enameling furnaces were converted, wings added to existing furnaces, and improvisation made in every place possible. It worked; guns and armor came off the line on time.

At this point it is perhaps in order to clarify any question as to what all this has to do with the steelmaker. It has been mentioned previously that the alloy-conservation program went all the way back to the steelmaker. It is just as true of all other properties steel must possess to fill the needs of Ordnance. Some of these are briefly reviewed in the following paragraphs.

INCREASING demands upon the performance of steel makes necessary the maintenance of *high quality*. The term "high quality" may be vague; at least, certainly, it is relative. High quality from Ordnance standards means the highest practicable level of cleanliness, ductility, and toughness, freedom from segregates and laminations, and consistent physical properties. All these characteristics start with the melter and are made fast by the ingot. Once in the ingot, there is not much that can be done about them. Some may ask: Will not steel as it has always been made do the job? The answer is—no, not consistently. Gun tubes and liners are designed with a factor of safety so near one that the difference between a clean forging and a laminated forging may be just enough to give the gun made from the laminated forging effective properties equivalent to a factor of safety of less than one. Armor has no factor of safety. Every time a piece of armor is subjected to the impact of a projectile it is stressed beyond the yield strength of the steel. The rate of strain at the point of impact is exceedingly high. Armor made from steel that contains laminations or excessive nonmetallic inclusions will not stand up. If armor is to be defeated by a projectile, we want it to do so by plastic deformation and not by cracking; then a single perforation may not even cause a casualty, and the tank may fight on. But, since armor on a fighting vehicle is a component part of the structure, if it cracks up the whole vehicle is out, and the rendering of casualties is then only a matter of the enemy getting in a few more well-aimed shots.

Quality goes further. Many of the applications of steel in ordnance matériel must be heat-treated to achieve the desired physical properties. In order to deliver a uniform product to the next user, the heat-treater must receive a uniform, high-quality product. Coördination of these features has brought out a most revolutionary method of making gun tubes—from seamless tubing. In that method, by the very nature of the process, the central segregation of the ingot is pushed toward the bore of the gun where the service stresses are highest instead of being removed, as in hollow-bored solid forgings. Ordnance research has shown that the metal in the vicinity of the rifling grooves in a gun tube is stressed beyond its elastic limit every time the gun is fired. It is apparent, then, that there must be a minimum of stress raisers (nonmetallic segregates act as stress raisers) in the metal. Careful melting control, ingot practice, and organized inspection have made possible the successful application of this mass-production method to the making of gun tubes.

There is much discussion of late about "quality control" and "statistical methods of inspection." Those tools are indeed a reality and with proper interpretation they can be and are being applied to the manufacture of gun tubes, greatly reducing the cost of inspection testing with no sacrifice in

quality of the accepted product. There is every reason to believe those methods can be applied as well to the manufacture of armor and welding. Let it be emphasized, however, that high metal quality is essential and that the quality level must be consistent.

WHY are ductility *and* toughness both desirable metallurgical characteristics? Are they not the same? In a sense, yes, but in the concept of usage, especially some Ordnance uses, no, not precisely. In the simple tensile test, two criteria are measured that are usually summed up into what is commonly known as ductility—elongation and reduction of area. They are indeed useful to know, and in applications involving static loading the behavior of a metal may reasonably be predicted from their consideration. In some Ordnance applications, like guns and armor, where factors of safety are low or nonexistent and rates of load application are exceedingly high, more has to be known. Recourse must be had to such tests as notched impact tests, like Charpy, Izod, or merely a simple notched section.

In this respect, the actual value of energy absorbed in rupture of the specimen is perhaps less important than the *type* of fracture observed. In the notched-bar test, two criteria are immediately apparent: first, the ability of the metal to withstand high shock loading and, secondly, the metal quality as earlier defined. Tough steels will respond to the notched-bar test by revealing a dull fibrous fracture caused by crystallographic deformation and consequent high energy absorption. Brittle (used in the sense of the opposite of toughness) steels respond by showing a bright crystalline fracture caused by intercrystalline or intracrystalline severing with no, or very little, crystallographic deformation and therefore little energy absorption. Laminations, excessive segregates, voids, etc., are also revealed in the fracture test and are most often reflected in nonuniformity of energy values.

Most people refer to tensile, yield, and fracture strengths as the tensile properties of a metal or alloy. By this time, the influence of the metal-making process is perhaps less pronounced than in quality or the fracture test. However, consistent mechanical properties in a metal are definitely related to the melting practice of the particular heat, and certainly one can expect consistently better tensile properties from a uniformly clean and well-processed heat of metal, particularly steel.

Clean and well-processed metal is particularly important in fatigue where imperfections all represent points of local stress concentrations which can result in early failure. Again referring to the highly stressed applications of Ordnance, one has to consider fatigue characteristics in the high-stress, low-cycle portion of the conventional S-N curve. Were it not for the fact that guns wear out l y erosion, they would surely be limited in life by fatigue, and this life would be in terms of thousands of cycles (rounds fired), rather than several million cycles as in the conventional fatigue test. Erosion, heat effects, strain propagation, and chemical changes in steel do play a most important part in establishing this limit.

A discussion of steelmaking in wartime is perhaps not complete without some mention of how our enemies are doing too. Before this, however, it is desired to describe briefly the facilities set up in the Ordnance Department for acquiring and evaluating technical data on enemy matériel. In the Research and Development Service of the Department is the Technical Intelligence Branch whose function is to oversee the receipt, allocation, study, and analysis of foreign matériel and materials. This office coördinates its activities closely with the War Department General Staff, the Director of Intelligence, Army Service Forces, and other agencies of the Government dealing in such matters. Ordnance has qualified and trained officers in every theater of operation, and it is the duty of these officers to gather as much information as they can on enemy matériel.

A goodly portion of captured matériel is returned to the United States or to our allies in England, where it is given a thorough study. Ordnance proving grounds and Ground Forces schools check the matériel from the standpoint of tactical operation and performance. Component parts are farmed out to research agencies, such as the Ordnance laboratories, National Defense Research Committee, and private research agencies who have offered their facilities to Ordnance. When reports are in, the engineering data are analyzed, evaluated, and compared with our own standards. Needless to say, if anything is found of value to our own Ordnance program, there is no hesitancy in using it.

THE Germans are excellent technicians. They know armament as we know automobiles. It is obvious they have planned their program for years. They do a consistently good job, and their matériel must be rated first class. They are judicious in the use of alloys, within the limits of those available to them. The steel is good; melting, refining, and heat-treating practice is generally beyond criticism. In the early stages of the war the captured German matériel showed in the heat-treated components, such as gun tubes, armor, engine parts, etc., ample hardenability with nickel and chromium in prominence. Lately these similar uses show a decided trend toward chromium and silicon to achieve the same hardenability. This trend is not without its detriments, as a certain amount of toughness is lost. Some of their important guns still use nickel as a principal alloying element.

Their armor is made from good steel, well treated; but with the alloying elements available to them they must necessarily go to higher carbon to achieve hardenability, and that works a tremendous hardship upon the weldability of the armor. Welded German armor is not a consistently good product. Also the trend in German armor seems to be toward higher hardness with consequent lack in ductility and therefore less resistance to the impact of large projectiles. The Germans spare no effort to find ways to defeat projectiles, including such emergency engineering as extra plates hung loosely on the vehicle or extra tank treads spread strategically on the front or sides of tanks. These are all admissions of the tremendous firepower of allied guns.

German high-explosive shells are made from normalized steel, which gives them lower properties than our shell steel. Consequently they must sacrifice explosive capacity by designing shell with thicker side walls and bases. German armor-piercing projectiles are well made from well heat treated steel.

The Japanese, however, are not as thorough as the Germans in their armament program, and it is also very evident their German allies are not helping them much in the technical aspects. Their steel practice is inferior, and their choice of alloys is not always judicious. There is no decided trend in alloy selection, and they seem to copy applications of others, even though the specific item copied is not current. There is little evidence of trends toward standardization, and designs are not generally adaptable to U. S. standards of mass production.

Aberdeen Proving Ground Post

Inauguration of the Twenty-fifth Chapter of the Association

THE Aberdeen Proving Ground Post, Army Ordnance Association, was established at historic ceremonies held at the proving ground on the afternoon of August 16, 1944. The occasion was also one of honor for Maj. Gen. C. T. Harris, Jr., commanding general of the proving ground, upon whom the General John H. Rice Gold Medal for distinguished Ordnance service was conferred. Some one thousand officers who are members of the new Post were in attendance as also were the chiefs of the thirteen Ordnance districts, key civilian members of their staffs, and members of the Ordnance District Advisory Boards. The principal address was made by Maj. Gen. L. H. Campbell, Jr., Chief of Ordnance.

Plans for the formation of a local chapter at the proving ground have been under way for several months. Sponsors of the project saw in such a local organization a method for bringing the facilities and operations of the national organization closer to proving-ground personnel. It is especially fitting that Aberdeen have its own local chapter, for it was here that the Army Ordnance Association was established just twenty-five years ago.

The newly elected officers of the post are: General Harris, president; Brig. Gen. Donald Armstrong, chief of the Ordnance Training Center at Aberdeen, vice-president; Maj. E. S. Palmer, treasurer; Maj. K. J. Hackett, secretary; and the following directors: Col. George G. Eddy, chief of the Ordnance Research and Development Center, Aberdeen; Lieut. Cols. M. L. Ehrmann, O. E. Hurlbut, and Oscar Kreiser.

In conferring the Rice Medal upon General Harris, the Association honors an officer of outstanding ability and long distinction in military affairs in this country. General Harris has served in important positions in the Department during two major wars. In World War I he was an originator and administrator of the great powder and explosives program required in that conflict. Following that war, he served as executive officer to General Rice who had lately been Chief Ordnance Officer of the American Expeditionary Forces in France. It was during this period of service with General Rice that General Harris assumed many of the characteristics which had marked General Rice's long service. Many friends of both officers have commented frequently upon this fact.

Throughout all the years of peace between the two World Wars, General Harris more than any one man led the forces of industrial-mobilization planning. Largely due to his service and efforts as chief of the Planning Branch, Office of the Assistant Secretary of War, those plans were brought to a high state of completion. He helped to draft the first version of the Industrial Mobilization Plan in 1932, and he

influenced in effective measure subsequent revisions of that document. The plans and policies it contained have proved themselves again and again in the winning of the present war.

THE announcement of the award to General Harris was made by Col. Frederick H. Payne, formerly Assistant Secretary of War in the cabinet of President Hoover, a vice-president of the Association, and chairman of its Committee on Award. Colonel Payne said:

"It is my privilege as chairman of the Committee on Award to make the following announcement. In recognition of his outstanding service to the Nation, the Army, the Ordnance Department, and the Army Ordnance Association, we wish to honor General Harris with the highest award at our disposal. For many years General Harris was closely associated with General John H. Rice.

"General Rice was one of the truly great officers in the history of the Ordnance Department. He was an engineer of outstanding attainments. He served as Chief Ordnance Officer of the American Expeditionary Forces in the first World War. Later he was chief of what is now the Industrial Service of the Department and the then Colonel Harris was his executive officer. Through all the years of General Harris' great work for the Department, the influence and characteristics of General Rice have been obvious to those of us who knew him. Therefore, it is especially fitting that the Rice Medal be conferred upon General Harris with the following citation:

" 'The Army Ordnance Association acclaims an outstanding Ordnance officer for his unsurpassed contribution to Ordnance progress. In Ordnance arsenal and depot he applied the best industrial techniques; in the War Department he prepared plans which resulted in the Industrial Mobilization Plan. At the beginning of the emergency preceding Pearl Harbor he moved with speed and efficiency in harnessing American industry to Ordnance production. Now, as commanding general of the world's foremost proving ground, he continues with outstanding skill the work to which his entire life has been devoted—Ordnance of superior quality and in adequate quantity for victory in war and security in peace.'

"I will now ask General Crowell to confer the award."

At the request of General Crowell *(center)* the medal, as shown in the photograph on p. 481, was presented to General Harris *(right)* by the Chief of Ordnance, General Campbell *(left)*.

In his address, General Campbell stressed the importance of present and postwar industrial strength as essential to our national security. He congratulated the members of the new Post upon their interest in Ordnance affairs and urged them to continue it throughout the years to come. He described the magnitude of the Ordnance research and development program, the cost of Ordnance production in lives and money, and the completeness with which American industry was compelled to disrupt its peacetime pursuits for war production. American industry must be supreme, he said, not only for our peacetime well-being but as a preventive of war, and never again must industrial strength be so jeopardized. Adequate strength in time of peace, he declared, is the best guarantee of our national safety.

"In the Army Ordnance Association," General Campbell said, "we have a nonpartisan, nonprofit-making society of American citizens with only one objective; namely, industrial preparedness as a guarantee of peace. It behooves American industry and all members of the Ordnance fraternity to see to it that the objectives of the Association are attained constantly through the years to come. Through adequate research and development, educational orders for industry, and a strong body of well-informed public opinion will come the strength required to enable our country to sustain the peace."

The charter of the new Post was presented to Col. James L. Walsh, vice-president of the Association and founder and first editor of ARMY ORDNANCE. Colonel Walsh spoke in high praise of the Ordnance effort in this war and urged all members of the new Post to carry forward with unflinching zeal the work so well begun by the Association at Aberdeen twenty-five years ago. Upon this organization, he declared, rests the grave responsibility of assuring our armament preparedness at all times and under all conditions. Our allegiance to the Ordnance cause must continue in the days of peace if we are to be spared the havoc of another World War.

General Harris presided as chairman of the meeting. Introductions of the several speakers were made by Col. L. A. Codd, executive assistant to the Chief of Ordnance.

Also seated on the dais were: General Armstrong; J. C. McHannan, director of the Cleveland Post; Colonel Eddy; Col. Henry P. Erwin, assistant treasurer, Army Ordnance Association; Ward Canaday, director of the Cleveland Post; Col. H. G. Stanton, executive officer, Aberdeen Proving Ground; and the following officers of the proving ground in addition to the newly elected officers and directors of the Post: Lieut. Cols. O. R. Schurig and W. C. Farmer; Majs. C. A. Gebhardt, J. A. Westbrook, and W. M. Teeter.

Following the meeting, the guests were taken to the parade ground where a military review of the Ordnance troops in training at Aberdeen was given. In the reviewing party were General Campbell, General Armstrong, General Crowell, and K. T. Keller, president of Chrysler Corporation, a member of the Advisory Board to the Chief of Ordnance, and a national director of the Association.

OF all Ordnance establishments in continental United States and abroad, none has played a more important part in the progress of American ordnance and of the Army Ordnance Association than has the Aberdeen Proving Ground. There, on October 24 and 25, 1919, the first annual meeting of the Association was held.

Prophetic indeed were these words of the then Chief of Ordnance, the great Maj. Gen. C. C. Williams, who was one of the principal speakers at that charter meeting at Aberdeen in 1919: "This gathering together today of responsible men of affairs in the Nation's industry is significant to me as indicating that in the future there is to be a joint trusteeship of the Ordnance problem. . . . To my mind it is absolutely essential that the Ordnance Department maintain its close connection and coöperation with the industries of the country. We want you to feel that way, and we feel that way, I know. We want to have our arsenals thrown open, so that the manufacturers of this country may go to them at any time they see fit and examine the manufacture of any of the war materials we are making. The more knowledge of that kind that is spread abroad throughout the country the better off the country is, because when war comes the thing we want above all other things is production, and I am sure that this Association is going to lend its influence and be a powerful influence in industrial preparedness which is so necessary if production is to be the chief thing in wartime."

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NOVEMBER-DECEMBER, 1944

Month by Month

Army Ordnance Report.—One of the most popular publications of the Army Ordnance Association in recent months is Army Ordnance Report No. 6, "Ordnance Ammunition Production." The author is the Hon. Albert J. Engel, U. S. Representative from Michigan and ranking member of the War Department Subcommittee, House Appropriations Committee. Demands for copies of the report are so great that it is now in its third printing.

Early this year, in the midst of war, Mr. Engel was authorized by the Secretary of War to inspect Ordnance manufacturing establishments "and therein to study the production costs and inspect records." He also had authority to take copies of records and data required, subject, of course, to such safeguards as the War Department deemed necessary. His purpose was to make a thorough study of Government-owned, company-operated powder and explosives, shell-loading, bag-loading, shell-forging, and chemical plants. He personally visited twenty-two of the fifty-eight Government-owned, company-operated plants of this type.

In his report, Mr. Engel describes the remarkable achievement of American industry in the production of powder, explosives, and the loading of artillery ammunition. He describes as "a miracle of production" the increase in output during the first four months of 1944 during which we produced more than twice as much powder and explosives as were produced during the entire year of 1941. During the years 1941, 1942, 1943, and the first 4 months of 1944, 6,000,000,000 pounds of powder and explosives were manufactured by these Industry-Ordnance plants.

On the much-discussed and frequently misrepresented subject of fixed fees, as compared with total operating costs, the Industry-Ordnance ammunition achievement is most enlightening. It shows a total operating cost of $1,477,130,000 and total fees of $65,002,287—a ratio of earned fee to cost of 4.4. Mr. Engel is loud in his praise of all components of American industry and the Ordnance Department which share in this phenomenal record.

Members of the Association are welcome to additional copies of the report, without cost. Here is a state paper of prime significance. It is proof positive that American industry and Army Ordnance are an invincible team in time of war. They must remain so in time of peace!

Matériel for Merrill.—Brig. Gen. Frank Dow Merrill, famed leader in Burma of Merrill's Marauders who recently returned to this country, expressed his deep appreciation of the excellent Ordnance supply service in the China-Burma-India theater.

"In quality and quantity," General Merrill said, "Ordnance battle tools and ammunition left nothing to be desired. Ordnance efficiently supplied the 3,000 American troops under my command with complete combat equipment in duplicate—two rifles, two bayonets, an extra supply of hand and rifle grenades, two ammunition belts—two of everything. So abundant was the ordnance matériel placed at our disposal that our biggest problem was to decide what to leave behind.

"After we entered the jungle we received our Ordnance replacement weapons and ammunition by air. There was no time for the field repair of our weapons because we were a fast-moving outfit operating in hostile territory. In 100 days we marched 750 miles down some of the roughest and toughest country in the world against unrelenting Jap opposition. But so efficient was the Ordnance supply system that our entire force, if the need had arisen, could have been furnished with a complete set of battle tools in twelve hours."

Aviation Ordnance.—The Ordnance Department paid high tribute to the Army Air Forces on the thirty-seventh anniversary of its foundation. In a congratulatory letter to Gen. H. H. Arnold, Chief of the Air Forces, on behalf of all Ordnance personnel, Maj. Gen. L. H. Campbell, Jr., Chief of Ordnance, declared that "never in the history of warfare has there been at hand for the winning of a conflict the power, speed, equipment, and trained organization such as are now under your command. We of the Ordnance Department take pride in the part we are privileged to play in coöperating with your great achievement."

During World War I, Ordnance and Air Corps designers and engineers installed new gun mounts on various types of fighter planes. For example, they put a 37-mm. cannon with a clip cartridge belt in the nose of a twin-engined Martin bomber and developed and mounted new types of Lewis and Browning fixed and flexible guns. Ordnance also developed demolition bombs which were of light-case steel filled with TNT and made in weights ranging

from 50 to 1,600 pounds. Fragmentation bombs a quarter of a century ago weighed 20 pounds and incendiary bombs about 50 pounds.

Following the World War, an intense development was begun by Ordnance on weapons solely for airplanes. In 1939, Ordnance was producing an aircraft caliber .30 machine gun that was dependable, adaptable to all types of installations, and could fire 1,200 rounds a minute. When armor plate and leakproof gas tanks made this gun inadequate, Ordnance produced the famed caliber .50 aircraft machine gun, which General Arnold has characterized as "the best gun for airplanes to date," and steadily improved armor-piercing, incendiary, and other types of aircraft ammunition. Today, Ordnance is supplying the Air Forces in all combat theaters with 20-mm., 37-mm., and 75-mm. cannon.

Following numerous tests and experiments, the Ordnance-Air Forces team fabricated a combined forged and welded bomb. This investigation led to the present general-purpose bomb which has a minimum case strength of 105,000 pounds per square inch and can be dropped without rupturing against a concrete slab. Using a delay-action fuze, bombs of this type can crash through to the basement of most buildings, bury themselves several feet in the ground near a bridge, or penetrate the deck of all seacraft except the heavily armored decks of heavy cruisers and battleships. Today Ordnance is supplying the Air Forces with the general-purpose bomb in five sizes, ranging from 100 to 2,000 pounds.

Ordnance also has provided the Air Forces with the parachute bomb, first used in the Battle of New Guinea, the proper fuzes for the minimum-bombing or skip-bombing technique, first used to wipe out a 22-ship Jap convoy in the Battle of the Bismarck Sea, and the blockbusters used in the European theater.

HEADQUARTERS
THIRD UNITED STATES ARMY
Office of the Commanding General
APO 403

5 September 1944

My dear Campbell:

Thanks very much for your note of congratulations which I just received.

I also wish to congratulate you and through you the members of the Ordnance Department for the magnificent material which has made the rapid advance of this army and all other American armies possible. Our material is really marvelous.

Again thanking you, and with all good wishes, I am,

Most sincerely,

***(Signed)* G. S. PATTON, JR.**
Lieut. Gen., U. S. Army, Commanding

Maj. Gen. L. H. Campbell, Jr.
Office of the Chief of Ordnance
War Department
Washington, D. C.

Automotive Equipment Reclaimed.—Great stocks of truck and automotive equipment, rushed to Alaska two years and more ago when a Japanese invasion appeared imminent, are now flowing back to Army Ordnance reclamation centers for reshipment to other war theaters. At the recently established returned-matériel center at the Twin Cities Ordnance Plant in Minneapolis, for example, seventy-five carloads of equipment have already been processed and put back into supply channels, and the reclamation program is being constantly accelerated.

Everything from huge truck tires to piston rings, from rear axles to fenders, is pouring into the center at the rate of three or four carloads a day. Skilled mechanics inspect it, sort out the good stuff from that which must be junked, clean it, and do everything necessary to put it back into shape for use.

The Ordnance Department is setting up these returned-matériel centers in Minneapolis, Minn.; Salt Lake City, Utah; Pottsville, Pa.; Anniston, Ala.; and St. Louis, Mo., to expedite the flow of needed equipment and to conserve equipment that would otherwise go to waste. Approximately 10,000 tons a month are currently being processed at the 5 Ordnance reclamation centers.

Ordnance Stock Control.—The Ordnance stock-control system is one of the most efficient in the history of modern warfare. The stock consists of some 2,200 separate major items, with nearly 400,000 different kinds of spare parts needed to keep them all in repair. Thousands of factories and millions of workers in every one of the forty-eight states are turning out these major items and spare parts at a phenomenal rate.

One of the major jobs is to keep careful check on each item in this enormous flood tide of material from the moment it leaves an assembly line until it reaches the front ready for combat use.

A system has been perfected whereby information regarding the location and quantity of each item is instantly available at Army Ordnance headquarters in Washington, whether the item is in transit here in the United States, being unloaded at a depot, in storage at any one of fifty-two depots in this country, being loaded on freight cars at a depot for overseas shipment, in the holds of Liberty ships on the high seas, at overseas base depots, or at advance depots close to the battle lines.

Two-Way Radio.—The leadership of the Ordnance Department in developing the use of 2-way radio communication between locomotives and a central train-dispatching point has attracted the attention of the Federal Communications Commission which is studying the Ordnance progress in connection with the allocation of wavelengths for the railroads of the Nation.

Ordnance Field Service, which operates the many Ordnance supply and ammunition depots throughout the country, began a year and a half ago to experiment, at the Savanna Ordnance depot, with 2-way radio operation between the engineer of a locomotive and the depot train dispatcher. The tests were so successful that this method of communication is rapidly being expanded to other Ordnance depots. Special wavelengths have been assigned to Ordnance depots by the Federal Communications Commission. These wavelengths usually cover a distance of approximately thirty miles.

Ordnance Research

An ditorial

AS victory for our armed forces comes closer on all the far-flung battle fronts, the vast superiority of American ordnance in all categories is in daily evidence. In the opinion of the soldier who is hourly using our guns and ammunition and in the judgment of the commentator who has seen our weapons in action, American firepower is supreme. More eloquently than any other one factor, American ordnance, as produced by the Industry-Ordnance team, brings to our fighting men on land, sea, and in the air, the strength which implements in kind their own heroic conduct.

In this feat alone, the coöperative endeavors of American science, industry, and Ordnance have merited the acclaim and thanks of all our people for generations to come. When victorious peace is ours, we must be prepared to keep America strong in its armament. This is the grave responsibility of the Ordnance Department and one which it assumes gladly.

The air is filled with postwar plans. For ourselves, we would prefer that these await the winning of the war on all fronts. But since popular opinion demands plans not only for demobilization but also for all sorts of peacetime progress, we of the Ordnance fraternity would be remiss in not asserting the vital necessity for ordnance research.

There can be no doubt that military armament now stands at the threshold of unknown vistas the ends of which seem to be limitless. Electronics, atomic energies, rockets, jet propulsion, to say nothing of metallurgical, chemical, and plastic progress, all pave the way to realms of research formerly unknown to the artillerist and tactician and even now unpredictable to the scientist. Let no one smile at the thought of robot bombs capable of ranges of thousands of miles. Let no one snicker at the thought of explosive forces powerful enough to shatter targets now relatively invulnerable to RDX, TNT, and our other most potent substances. Let no one, especially among those of us who know the importance of ordnance, gainsay the yet-to-be-developed advances of air power, naval power, and mechanized warfare. All have proved themselves many times over in battle, and all are but the beginning of velocity warfare which will characterize combat of the future.

Even at this time when the war against Germany is coming to a victorious close and the war against Japan is reaching a mighty climax, he who contends that our armament of 1944 represents the acme of offensive and defensive power is asleep. Upon our proficiency in ordnance research and upon our industrial strength, ready for *instantaneous use,* rests the foundation of our national security.

What then is the form of ordnance research organization required to guarantee superiority of firepower in these days of velocity warfare? Most important will be the marshaling of the best scientific brain power of our country for this continuing task. From our great private research laboratories, from our educational institutions, and from our technical and scientific societies must come the prosecution of particular ordnance research projects. In these institutions is the breadth of vision, the knowledge, and the scientific apparatus for continued research and development. These, in coöperation with such long-established agencies as the National Research Council and the National Defense Research Committee, are equipped to work hand in hand with the Ordnance Department of the Army for armament progress.

We seriously question the need or desirability for the establishment of vast governmental enterprises for weapon research. There are plenty of such facilities already, and they should be reduced rather than expanded. "Big government" is not the answer to weapons research for the future. The answer is in the hands of private research and educational organizations coöperating with the time-honored experience and engineering direction of the Ordnance Department of the Army.

THIS viewpoint was best expressed by Maj. Gen. Levin H. Campbell, Jr., speaking before the Franklin Institute of Philadelphia, September 9, 1944, when he said:

"The record of weapon research and development until 1940 is not a glorious one. The Ordnance Department of the Army, responsible for the design and development of our fighting equipment, did not receive in time of peace funds sufficient to carry forward research on a scale equal to any of our comparable industrial organizations. It was a great day for weapon progress in our country ten years ago when as much—or as little—as $7,000,000 was appropriated in one year, not for research and development, mind you, but for the operation of the entire Ordnance Department of the Army—its arsenals, depots, and proving grounds! Yet when war came, that responsibility rose in money value to more than $50,000,000,000 in one year.

"Those figures speak for themselves, and I will not attempt to elaborate on them. I will only record the firm belief that our weapon superiority—and therefore our national security—in the years to come will be in direct ratio to the time, energy, and money we allot to armament research and development. Adequate funds will be a small premium to allot to this form of national peace insurance. Let us hope that our experiences in this war will confirm all our fellow citizens in the wisdom and urgency of such a course.

"Further than that, let me suggest that armament research and development for victory now, and peace in the years to come, can best be carried forward by the scientific, technical, and industrial establishments of our country. Armament progress needs the impetus of free competitive research. It will never be at its best under bureaucratic control, but will thrive only when the brain power of our Nation at large is given to the task. Thus I would urge that armament research, after the peace is won, be carried on for the Ordnance Department of the Army by such establishments as the Franklin Institute. . . Here, and in countless other research laboratories, this work should be done. The traditional viewpoint of Army Ordnance is to utilize the facilities of private industry. This applies to the laboratory as well as to the factory."

With this program of research under the direction of the Ordnance authorities of the Army and Navy, the scientific and industrial forces of our country can guarantee an alert program worthy of the financial support of the Nation and the moral backing of all our citizens.

Association Affairs

GENERAL REIMEL HONORED IN NEW YORK

SOME 300 representatives of industry in the New York Ordnance District honored Brig. Gen. Stewart E. Reimel, chief of the district, at a meeting and luncheon on September 21, 1944. The gathering was held at the Waldorf-Astoria Hotel. R. E. Gillmor, president of the Sperry Gyroscope Company and president of the New York Post, Army Ordnance Association, presided. Harry M. Tillinghast, president of R. Hoe & Company, and first vice-president of the New York Post, introduced the guest of honor.

General Reimel brings to his new post, as chief of the New York Ordnance District, a wealth of experience in the use and manufacture of ordnance. He succeeds Col. Gilbert I. Ross, an officer of splendid attainments who, as a member of the Ordnance Reserve, has served the Ordnance Department and the New York Ordnance District through some of their most difficult days. He has returned to inactive military status to resume his professional engineering practice.

During World War I, General Reimel was an Infantry officer, participating in the Aisne defensive, the occupation of the Marne sector, the Champagne-Marne defensive, the Aisne-Marne offensive, the St.-Mihiel offensive, including the Meuse-Argonne offensive in which he was wounded.

Subsequently, General Reimel turned to Ordnance, served at many arsenals, as camp and corps-area Ordnance officer, and in many executive positions in the Offices of the Chief of Ordnance and the Under Secretary of War.

More recently, General Reimel has been chief of the machine-tool branch both of the Resources Division, A.S.F., and the Army and Navy Munitions Board. He comes to the district from the important assignment of chief of the Maintenance Division of the Office, Chief of Ordnance, Detroit. During the past six months, as the personal representative of the Chief of Ordnance, General Reimel visited the three Pacific theaters of war—Southwest under General MacArthur, South under Admiral Halsey, and Central under Admiral Nimitz.

Mr. Tillinghast announced a series of Ordnance meetings and lectures to be held during the fall and winter months. The lectures are being given by members and faculty of the Ordnance School, Aberdeen Proving Ground, and are being held on the first Tuesday of each month in the auditorium of the Engineering Societies Building, 29 West 39th Street, New York City. The general theme of the lectures is "Our Armament in Battle." The first lecture, at which Col. Willis R. Slaughter, commandant of the Ordnance School, presided, was devoted to field artillery and heavy mobile guns. The lecture was given by Capt. Halsted James, Jr., assisted by the following officers of the school faculty who participated in a general round-table discussion and who answered questions from the floor on the assigned subject: Maj. M. R. Vick, Capt. F. D. Dolan, and Lieut. William C. Fels.

ROCKY MOUNTAIN POST

THE annual dinner meeting of the Rocky Mountain Post of the Association was held in the Silver Glade Room of the Cosmopolitan Hotel, Denver, Colo., on September 15, 1944. The featured speaker of the evening was Brig. Gen. Rosswell E. Hardy, chief of the Ammunition Division, Ordnance Industrial Service.

The meeting was conducted by James D. Maitland, president of the Post. The following honored guests attended the meeting from out of town: Col. Clyde H. Morgan, chief of the St. Louis Ordnance District; Col. R. W. Coward, assistant chief of the St. Louis Ordnance District; Donald F. Carpenter, vice-president and director of manufacture of Remington Arms, Inc.; Karl E. Vogel, president of the Nebraska Post; Capt. F. G. Arkoosh, secretary-treasurer of the Nebraska Post; and Julian Bamberger, president of the Bamberger Railroad Company of Utah.

General Hardy clarified the present position of the procuring services of the Army by stating that the field commanders in battle have demonstrated their ability successfully to wage offensives when adequately supplied with arms, equipment, and supplies and that, until the last shot is fired, the home front can do no less than to keep the supplies moving at top speed to the fighting fronts.

Capt. James Colasanti, Post secretary-treasurer, presented to the membership a plan of research, study, and investigation of Ordnance weapons and their manufacture to be participated in by all the members of the Post. Group chairmen were appointed to lead the activity of their particular groups which will devote their efforts to the ultimate objective of improving the design and manufacture of the following six classes of ordnance matériel: ammunition, artillery, tank-automotive equipment, small arms, fire-control instruments, and aircraft armament.

LIEUT. COL. WHITNEY STONE

WHEN Col. Henry B. Sheets recently became chief of the Boston Ordnance District, he took over the weighty responsibility of that office from its deputy chief, Lieut. Col. Whitney Stone, who had served in that capacity since the departure of Brig. Gen. Burton O. Lewis to become Chief of the Transportation Corps of the Army.

Lieut. Col. Whitney Stone

Colonel Stone, a leading figure in industry and formerly a member of the well-known engineering firm of Stone & Webster, entered the Ordnance Department early in the present emergency as a deputy chief of the New York Ordnance District. There he gave yeoman service in helping to organize and administer, under Col. J. K. Clement, then district chief, the vast organization which was so efficiently built up in that area.

Well known in financial and industrial circles, Colonel Stone brought to the Ordnance organization, not only in New York but also throughout the Nation, a broad experience and contact with many leading business enterprises. During his tenure as deputy chief of the Boston Ordnance District the Ordnance record in that region remained of the highest and reflected Colonel Stone's industrial ability and pleasing personality. He continues as deputy chief at Boston.

OFFICE OF FIELD DIRECTOR OF AMMUNITION PLANTS CELEBRATES ITS SECOND ANNIVERSARY

THE Office of the Field Director of Ammunition Plants, a branch of the Ammunition Division, Office of the Chief of Ordnance, located in St. Louis, Mo., celebrated its second anniversary at the Chase Hotel in St. Louis on August 5, 1944. The office was established August 1, 1942, in accordance with Ordnance Department Order No. 305, with Col. T. C. Gerber as the field director. Colonel Gerber is also Director of Safety, Safety and Security Division, Office, Chief of Ordnance, Chicago.

The meeting was the climax of a 2-day conference held in the

CORP. EDWARD BOWES (IN CIRCLE) CHAMPION RIFLE SHOT, BATTERY D, 2ND ARTILLERY, CALIFORNIA NATIONAL GUARD, 1893

Office of the Field Director of Ammunition Plants and was attended by the commanding officers and plant managers of the sixty-five Government-owned, contractor-operated Ordnance ammunition facilities under the jurisdiction of the Ammunition Division. The conference was called by Colonel Gerber for the purpose of outlining procedures to be followed in working out man-power and production problems and difficulties connected with the ammunition industry's increased requirements occasioned by the greatly augmented demand for heavy artillery.

In addressing the conference, Brig. Gen. Rosswell E. Hardy, chief of the Ammunition Division, Office of the Chief of Ordnance, said: "The requests for ammunition have been increasing; consequently it is necessary that the output of ammunition continue to go up. Every effort will be made to meet all ammunition requirements for the fighting fronts, and this effort must be continued until the end of the war."

After the broadcast, dinner was served for approximately 520 members of the Industry-Ordnance team, including officers, contractor executives, Ordnance personnel, and guests. Immediately after the dinner, the meeting was addressed by Maj. Gen. L. H. Campbell, Jr., Chief of Ordnance, who congratulated members of the Industry-Ordnance team on the excellent job they had done in the past and reminded them that the war was not yet over. Every one connected with the ammunition program, General Campbell said, must redouble his efforts in order that the greatly increased requirements for heavy artillery and other ammunition could be met. General Campbell also reminded those present that after they had completed their job of furnishing arms and ammunition for this war, it was the responsibility of the Industry-Ordnance team to see that Army Ordnance maintained its ability to produce superior weapons during peacetime. During the course of his talk, General Campbell presented an award for exceptional civilian service to J. F. Daley, former Deputy Field Director of Ammunition Plants, and also announced the appointment of J. A. Meek, production executive of the Firestone Tire & Rubber Company, as the new Deputy Field Director.

Out of this meeting, it is intended that an Ammunition Division of the Army Ordnance Association will materialize. This division, under a committee of leaders in the industry and as a unit of the Army Ordnance Association, will continue the studies begun in time of war so that our peacetime preparedness will have the benefit of their knowledge. Proposal has been made that one hundred members of each such company enroll as individual members of the Army Ordnance Association and as members of its Ammunition Division. It is also proposed that similar divisions—automotive, metals, etc.—be organized, all as elements of the Army Ordnance Association. Brig. Gen. Benedict Crowell, president of the Association, has invited the following gentlemen to serve on the Ammunition Industry Division Committee: Harvey C. Knowles, Procter & Gamble, Cincinnati, chairman; Arnold Hanger, Silas Mason Company, New York; Harvey Firestone, Firestone Tire & Rubber Company, Akron; and Kenneth A. Spencer, Military Chemical Works, Kansas City, Mo.

MAJOR BOWES NO ORDNANCE AMATEUR

THE beloved and popular Maj. Edward Bowes of radio fame is among the recently enrolled members of the Army Ordnance Association. He became a member in response to the invitation of K. T. Keller, president of Chrysler Corporation, recently elected a director of the Association. All members of the society will join heartily in a special welcome to the Major.

We take the liberty of publishing here excerpts from his letter to Mr. Keller:

"I am glad to have your very interesting letter, and, of course, I am only too happy to become a member of the Ordnance Association. Enclosed is a check for my 3-year membership. As you explain it, the purpose is simple enough. And what a big idea it is and what a powerful source for good it can become!

"Speaking of Ordnance, I am sending you an old photograph taken in 1893. In my hand you will note an old-fashioned Springfield rifle—the best to be had by an Infantryman at the time. But on the 'brawny' chest you will see evidence that the bullet knew where to go when I pulled the trigger!

"I sent one of these photographs to Lieut. Gen. Hugh A. Drum, and he wrote me that the uniform worn by me in this photograph was the same he first wore when he joined the Regular Establishment in 1898."

The photograph to which Major Bowes refers is published above. It is doubly interesting because of the early likeness of the Major and of the contrast in uniform and equipment between the early 1890's and today.

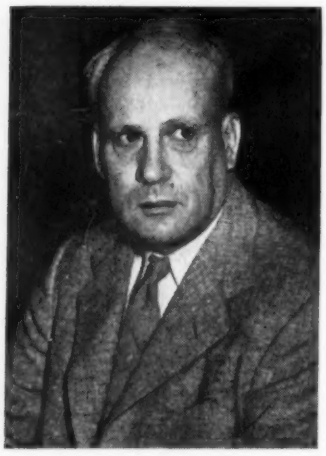
CHICAGO POST

THE following officers and directors of the Chicago Post, Army Ordnance Association, were recently elected to office by letter ballot: President: Brig. Gen. T. S. Hammond, president, Whiting Corporation; vice-president: Col. John Slezak, chief, Chicago Ordnance District; directors: E. J. Bush, vice-presi-

dent, Diamond T Motor Car Company; W. E. Crocombe, president, American Brake Shoe & Foundry Company; W. H. Damon, assistant cashier, Northern Trust Company; Thomas Drever, president, American Steel Foundries; Henry Isham, chief, purchasing, termination and renegotiation policy, Chicago Ordnance District; James Knowlson, president and chairman of the board, Stewart-Warner Corporation; C. A. Liddle, president, Pullman-Standard Car Manufacturing Company; Fowler McCormick, president, International Harvester Company; Sterling Morton, secretary and director, Morton Salt Company; F. A. Preston, vice-president, Poor & Company; E. A. Russell, vice-president, Otis Elevator Company; W. R. Wright, Chicago manager, Ford, Bacon & Davis, Inc.

DAYTON A. GURNEY RETIRES

DAYTON A. GURNEY, ordnance engineer of world-wide renown as a designer of modern artillery, has retired from active service after thirty-nine years of outstanding achievement for the Ordnance Department of the Army. Few men in military or civil life have contributed so much to the development of artillery. The superiority of our guns on the battle fronts of the world is as much attributable to the engineering prowess of Dayton Gurney as to any other one man.



Dayton A. Gurney

The best appreciation of his long service was expressed by Maj. Gen. L. H. Campbell, Jr., Chief of Ordnance, in a letter dated August 19, 1944, in which he wrote in part:

"All of the significant developments that have been made in modern American ordnance have occurred during your tenure, first as skilled draftsman, then as ordnance engineer, and finally as chief ordnance engineer in the Artillery Division. For thirty-nine years your skill and ability and personality have been reflected in the design, development, and production of American artillery that in this war is not surpassed by any other nation. We of Ordnance know that the development of the cannon that today are blazing the way for victory on world-wide battlefronts is not the result of any short-term effort. The superiority of American firepower in this war was made possible only through the painstaking efforts of Ordnancemen like you, who have devoted lifetimes to the development of the weapons we would need when our Nation was imperiled.

"For many years you shared responsibility for both the design of Ordnance artillery and the small production of cannon permitted by limited peacetime appropriations. When war came, your profound knowledge and great experience have been devoted to the herculean problems involved in the mass production of tremendous quantities of artillery weapons. At the same time you were always available as expert consultant on all phases of the design problems in which you were so well qualified. In short, your contribution to the success of American arms in this war has been immeasurable. . . All of us are grateful for your contributions to Ordnance progress. The patriotism which has at all times motivated your actions will be a lasting inspiration for each of us."

With these sentiments, so well expressed by General Campbell, all Ordnance leaders will concur enthusiastically. They join, too, in felicitations to Mr. Gurney who has been a member of the Army Ordnance Association since its foundation in 1919.

ARMY ORDNANCE NOW AVAILABLE ON MICROFILM

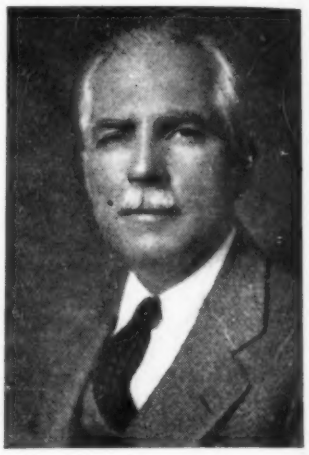
THE Library of Congress now is able to make available to schools, other libraries, and interested individuals microfilm copies of the complete file of the Association's journal, ARMY ORDNANCE.

Complete bound files of the magazine are no longer available for public distribution. However, the Library of Congress file, consisting of over 12,500 pages, is complete, and this has been used to make the microfilm copy. The cost of preparing the negative has been defrayed by the Army Ordnance Association which has also deposited the negative in the Library of Congress in order that other libraries and institutions may obtain copies of the entire file for $40.00 a set. The file on microfilm runs from Vol. I, No. 1 (the issue of July-August 1920) through Vol. XXVI, No. 144 (May-June 1944). Copies, on 10 reels of microfilm, are over 800 feet in length.

Orders should be addressed to the Photoduplication Service, The Library of Congress, Washington 25, D. C.

RUSSELL E. GARDNER, JR.

SPECIAL thanks are tendered by the Army Ordnance Association to Russell E. Gardner, Jr., who lately relinquished his duties as chief of the St. Louis Ordnance District to return to private business. He became deputy chief of the district June 16, 1943, and succeeded Col. Merle H. Davis as chief on March 31, 1944. His successor is Col. Clyde H. Morgan, an officer of the Regular Army, who has an outstanding Ordnance record.



Russell E. Gardner, Jr.

Mr. Gardner directed the vast operations of the St. Louis Ordnance District during a most important period. Under his guidance, the Department overcame some of its greatest obstacles in Ordnance production. All Ordnancemen are grateful to him for his leadership and help. He is an official of many industrial and financial institutions and was formerly a director of the St. Louis Chamber of Commerce, governor of the New York Stock Exchange, and president of the Princeton Club of St. Louis. The Ordnance Department is fortunate in having him continue as a member of the district's advisory board.

NECROLOGY

NOTICE has been received of the deaths of the following members of the Association: G. A. Anderson, Cincinnati, Ohio; Frank M. Andrews, Fort Thomas, Ky.; G. M. Bowen, Detroit, Mich.; A. N. Bradford, Sterling, Ill.; J. S. Clapper, Minneapolis, Minn.; G. L. L. Davis, St. Louis, Mo.; Ernest du Pont, Wilmington, Del.; Charles M. Frisse, Evansville, Ind.; Paul W. Gerdes, Fort George G. Meade, Md.; William W. Gibson, Vineyard Haven, Mass.; J. M. Gillespie, Pittsburgh, Pa.; S. J. Huber, Muskegon, Mich.; Frank H. Knoll, New York, N. Y.; James A. Nolan, Rochester, N. Y.; Herbert O'Leary, Governors Island, N. Y.; Robert J. Owen, Indianapolis, Ind.; R. G. Packard, Jr., Morristown, N. J.; George N. Peek, Moline, Ill.; Harry F. Plagenz, Cleveland, Ohio; Theo. I. Stein, Evansville, Ind.; Lester E. Swinehart, Bryn Mawr, Pa.; Harry P. Turner, Atglen, Pa.; E. C. Xander, Moline, Ill. To their relatives and friends, ARMY ORDNANCE, on behalf of the Association membership, extends condolences.

New Developments

A Superexplosive for Rocket Projectiles

PENTOLITE, an explosive twenty per cent more powerful than TNT, is being used in America's rocket projectiles. A small quantity of this explosive will blow a 2-inch hole through five feet of reënforced concrete, according to Maj. Gen. L. H. Campbell, Jr., Chief of Ordnance.

In addition to providing terrific punch for bazooka ammunition and other rocket projectiles, Pentolite also is employed in rifle grenades, antitank explosives, certain types of artillery shells, for demolition work, and for clearing wrecked harbors such as that of Cherbourg, France.

Pentolite's history begins in 1891 with that of PETN, or pentaerythritol tetranitrate, which was invented in that year. PETN alone is 40 per cent more powerful than TNT. Army Ordnance experimented with PETN at the Picatinny Arsenal, Dover, N. J., during World War I. It was found so sensitive to friction that it was considered too dangerous to manufacture at that time. Army Ordnance eventually found a way to utilize PETN by mixing it with TNT and thus producing safely and in large quantities the superexplosive, Pentolite. Important factors in this were greater purity of materials and closer control of manufacturing processes.

The Pentolite now being produced by Army Ordnance is made by nitrating an alcohol which, in turn, is made by treating a mixture of formaldehyde and acetaldehyde with lime. Used as a booster, detonator, or filler in various kinds of projectiles, it does not react with metals. Further, it can be heated below the boiling point of water and, in a pasty form, can be poured into shells—a much faster method than press loading projectiles.

New Armor-Piercing Projectiles

THE Ordnance Department has developed new armor-piercing projectiles that are twelve per cent better than those previously used against the enemy. This development occurred at a time when the steel industry's rolling capacity was taxed to the limit. However, through research and with the close coöperation of industry, Ordnance discovered that old-style shot could be reforged and converted into a new type projectile.

At the time this change occurred, the Ordnance Department had on hand 21,562,007 old-style projectiles ready for loading with explosives. In making the conversion to the new projectiles, 179,631,849 pounds of duo-alloy steel were salvaged and reused, thus saving many precious man-hours in the steel industry and giving our invasion forces greater firepower.

Taxpayers' savings were large: A saving of from an average of twenty-five cents on the 37-mm. projectile to an average of one dollar on the larger-caliber projectiles was made in remachining the restruck forgings, as contrasted with the cost of the projectiles from new bar stock.

A new armor-piercing incendiary bullet also has been devised by Army Ordnance and is being used by American airmen on all battle fronts. The bullet is the most recent development in the continuous bid for supremacy between offensive weapons and protective armor. Early in the war the self-sealing gasoline tank, which prevented leakage of fuel and formation of explosive vapor, was adequate protection against tracer bullets. Last year, however, a caliber .50 incendiary bullet, able to explode in a pierced tank, was introduced.

The enemy's answer to this was protective armor on airplane tanks. Research was expedited in the Ordnance Department, and the result is the new armor-piercing incendiary projectile, which combines penetrative ability with inflammatory properties. The new bullet, now in mass production, has been supplied in large quantities to our Air Forces in Europe and the Southwest Pacific.

"Spike Bombs" Destroy Jap Railroads

"SPIKE bombs," improvised in Burma to meet a critical situation, are being used with success to destroy Japanese-held railroads and bridges in the India-Burma sector. It was found that ordinary 100-pound bombs with delayed-action fuzes would not always remain squarely between the tracks but had a tendency to ricochet and explode a few feet away; yet delayed-action bombs were necessary in order to allow the low-flying planes time to get away from the blast.

The necessity for making bombs stick where they landed led to the development of spike bombs. They were made by taking out the nose fuze of each bomb and putting in its place a spike made of an old axle with one end threaded to screw into the missile and the other sharpened to a point. The new type bombs are now made to order in this country.

The Jungle Mortar T18E6

THE new Ordnance 60-mm. mortar T18E6 consists of the 60-mm. mortar tube and a combination base cap and firing mechanism. It is a lightweight weapon, primarily intended for jungle fighting against the Japs. It differs from the standard 60-mm. mortar, which it supplements, in that it can be carried by one man, together with a limited supply of ammunition, and

THE JUNGLE MORTAR IN ACTION

it is fired by a trigger-and-lanyard arrangement. It can be fired at angles of elevation outside the limits of the standard 60-mm. mortar.

The new mortar is based on a tree, log, or other stable object and provides rapid fire against pillboxes, machine-gun emplacements, and other enemy strong points.

The 9-mm. M3 Submachine Gun

THE Ordnance Department is supplying the European underground with thousands of M3 submachine guns that have been designed to fire 9-mm. German ammunition instead of the caliber .45 bullets supplied our troops. For some time production has been under way on a barrel, bolt, and magazine which, when inserted in the standard gun, will fire 9-mm. enemy ammunition. Ordnance is also supplying the underground with an initial supply of 9-mm. bullets.

The M3 submachine gun weighs less than 9 pounds and is capable of firing 450 bullets a minute. Each clip contains 30 bullets. Long before our troops landed in France, Ordnance supplied tens of thousands of these weapons to the underground

RUST!!

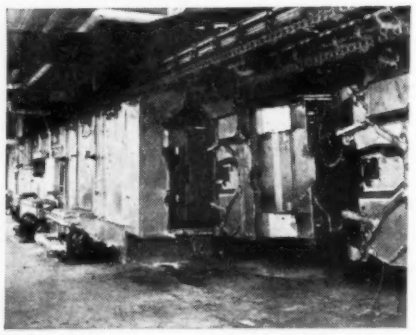
Prevention or Removal

Rust Problems Now Effectively Overcome

Rust, especially during rainy, humid weather, often becomes so troublesome as to seriously interfere with the steady flow of production. Rust can disrupt the whole production line and cause serious bottlenecks unless steps are taken to prevent or remove it during fabrication. With ACP Deoxidines rust removal becomes a simple matter of routine.

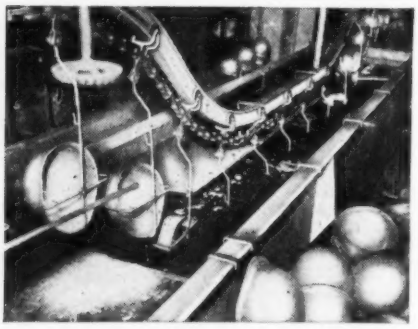
RUST REMOVAL — There are types of Deoxidine adapted for use in large, continuous, mechanized production in power spray washers that remove both rust and oil. Other types are adapted to immersion processes that may be mechanized or manually operated to suit production needs. There are still other types for hand wiping processes to remove occasional light rust that otherwise would require slower and more laborious mechanical operations.

These and other Deoxidines not only clean the metal — removing rust and destroying or inhibiting rust producers — they also properly condition it for painting.



A—Spray types of Deoxidine are adapted to the cleaning and processing of large surfaces in quantity production.

RUST PREVENTION — Peroline, a combined chemical and oil, not only provides a thin oil coating, effective in retarding rust, but it is unique in that it removes blushes of rust and marks from sweaty hands and destroys visible or invisible chemicals that would develop rust under conventional preventive coatings. While the amount of rust removal with Peroline is limited, its ability to remove thin coatings will often eliminate a separate cleaning or salvaging operation.



B—An immersion type of Deoxidine is well suited to the rapid cleaning of helmets with mechanized equipment.

Today, Deoxidine, Peroline and other ACP Chemicals are aiding in the production of many war essentials. They are aiding in salvaging various items which, due to improper cleaning or lack of proper protection, have become rusted during fabrication and storage. They are helping to insure satisfactory finishes and are minimizing rejections in the production of many vital war supplies including Shells, Rockets, Ammunition Containers, Automotive Equipment (jeeps, tanks, trucks, etc.), Marine Equipment, Aircraft and Aircraft Parts, Signal Corps Equipment and hundreds of miscellaneous components.

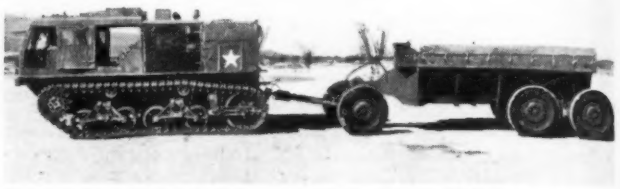
Further information on rust removal or prevention and Service Data Sheets on Deoxidine and Peroline may be obtained by addressing the American Chemical Paint Company, Ambler H 11, Penna.

New Developments

who would then raid German supply dumps to get additional ammunition. The 9-mm. bullet is used in German submachine guns and pistols.

Artillery Ammunition Trailer

As part of its enlarged heavy-artillery and heavy-artillery-ammunition program, the Ordnance Department is building a large number of 8-ton ammunition trailers. The new trailers are being used in global combat zones three in tandem and will carry ammunition for the 155-mm. "Long Tom" gun, the 8-inch howitzer, the 8-inch (200-mm.) gun, and the 240-mm. howitzer.



The M4 Tractor and the 8-ton Trailer

The trailers are towed on roads or across country by high-speed trucks or tractors. They are equipped with 11.00 x 20, 12-ply tires to correspond to the equipment used on the 155-mm. gun. One spare tire and wheel assembly is provided for each trailer. The new Ordnance vehicle can carry one of the following loads of steel and high explosive: 6 tons of 155-mm. ammunition, 6 tons of 8-inch howitzer ammunition, 5 tons of 8-inch gun ammunition, or 7 tons of 240-mm. howitzer ammunition. The trailer measures approximately 9 feet high, 7 feet wide, and, with limber, 22 feet long.

Flame-Throwing Tanks

Marines on Saipan, Marianas Islands, combined two old weapons to produce a spectacular new one with devastating effect. It is the flame-throwing tank. Under the type of fighting which took place there, with the Japanese soldiers well entrenched in mountain caves and cliffside dugouts, it was a godsend to our Infantry.

The tanks also were widely used in advances through sugarcane fields, where Japanese snipers frequently hid. One burst of a tank flame thrower burns a large section of field. Abandoned houses in which the Japanese frequently concealed machine guns were burned while our Infantry remained a comparatively safe distance behind. Even wells which could have harbored a sniper or two were given a brief singeing for good measure.

Against this weapon, the Japanese were able to offer little resistance. Cannon-bearing tanks frequently covered the flame-throwing tanks when advancing against fortifications to knock out antitank guns. Their destructive power was immediate and intense. In the slow hill-to-hill, cave-to-cave fighting which characterized so much of the battle on Saipan, the flame-throwing tank was one of the most formidable weapons the Japs encountered.

Steel Paracrates for Air-Borne Artillery

A new steel package for air-borne field-artillery operations has been developed. As a result of extended field tests, the Ordnance Department is replacing plywood paracrates and paracaissons with corrugated-steel crates for dropping the component parts of the 75-mm. pack howitzer.

A number of steel crates were shipped from the Ordnance

New Developments

arsenal at Rock Island, Ill., to the Airborne Center of the Army Ground Forces at Camp Mackall, N. C. The containers were packed in the prescribed manner and were drop-tested from various altitudes on soft sandy soil, on well-packed sand and gravel, and, finally, on an airfield concrete runway. No damage occurred to equipment contained in the steel paracrates and paracaissons in any of the drop tests. The crates, although slightly dented, were not rendered unserviceable even after being dropped on the concrete runway, and they would be able to be used again if required.

Results showed that the steel cases displayed greater strength and durability, when subjected to severe shock, than the plywood cases; that the construction and design of the steel cases simplified the packing of the howitzer parts; and that the parts were afforded greater protection.

A typical paracrate measures 51 inches in length, 18 inches in width, and 17 inches in height. The container, an oval cylinder, opens into two equal sections along its long axis. The wheels of the crate, designed to expedite removal of the howitzer components from the air strip, are stored in the front compartment while ammunition for the howitzer is strapped in the rear compartment.

The 75-mm. pack howitzer was first dropped with paratroopers to blaze the way for invasion ground forces in New Guinea. Ideal for beachhead landings, it can stand off at 7,500 yards—more than 4 miles—and drop a wickedly destructive 15-pound high-explosive shell on a jungle crossroad. The howitzer contains forty-three parts that can be assembled without the aid of a single tool. Total weight of the weapon in firing position is 1,269 pounds. Rate of fire of the 75-mm. pack howitzer is six rounds a minute.

THE TANKDOZER, NEW "SECRET WEAPON"

THE hedgerows of Normandy, behind which Nazi soldiers took cover and held off allied attackers with machine-gun, mortar, and tank fire, yielded to the tankdozer, a new break-through weapon developed coöperatively by the Corps of Engineers and the Ordnance Department.

THE TANKDOZER

Consisting of a huge bulldozer blade mounted on an M4 General Sherman tank, the new tankdozer combines some of the best features of both machines—the terrific work power of the bulldozer plus the striking power and protection of the tank. Few obstacles can stand in the way of the 3½-ton blade, backed by the driving force of the medium tank. It is intended that the tankdozer will be used in place of ordinary tractor-dozers only in cases where armored protection and firepower are needed to break a roadway through places under enemy attack.

RESULTS OF RESEARCH IN WAR CHEMISTRY

These Practical Products Have Been Developed through Research in Colloidal Chemistry and May Be Found Applicable to Your Business.

Self-Emulsifying Safety Solvent dilutes with water to replace naphtha, gasoline, or benzine for grease-cleaning, hand-wiping operations in metals-processing plants. Contains no chlorinated compounds, has no flash or fire point and does not tend to defat the skin. (Data Sheet # 235)

Hydro-Sealed by floating water blanket, new high-performance Carbon Gum Digestive Solvent cleans carbon and paint from aircraft engine parts without harmful effect. Used hot, water seal prevents escape of solvent vapors. (Data Sheet # 236)

High-Potency Concentrate makes Self-Emulsifying Grease Solvent to remove insulating coats of grease and dirt from truck, jeep, tank, and automobile engines by emulsification and utilizing the heat of a warm engine. Cleaned engines operate more economically since original thermal efficiency is restored. (Data Sheet # 237)

Unique Oil removes salt; may be applied to metal surfaces wet with sea water. Cleans, dehydrates and leaves thin film of rust-preventive compound. Suitable as a cleaner-preservative and lubricant for small-arms bore cleaning. (Data Sheet # 238)

High-Boiling Dehydrating Oil absorbs residual water from parts, storage tanks or equipment. Recovery for repeated use made by simple heating above 212° F. (Data Sheet # 239)

Trichlorethylene Replacement . . . non-volatile cleaning and scouring solvent for large cold immersion tank . . . rinses with hot water. Long solution life. (Data Sheet # 240)

New Fuel Concentrate raises low-test gasoline to high anti-knock rating motor fuel . . . especially applicable for high-compression motorcycle engines . . . increases performance. (Data Sheet # 241)

Sparkling Clear, water-in-oil cooling compound emulsion facilitates work inspections without stopping tools in metal-cutting and grinding operations. (Data Sheet # 242)

Emulsifying Compound cleans oil from camouflage paints; restores dead, flat, lusterless surface. Shipped as a concentrate. (Data Sheet # 243)

Instrument Shampoo emulsifying solvent cleans optical lens and delicate mechanisms without harmful effect. Results in physically clean work and complete absence of any film. (Data Sheet # 244)

Fluid, Pre-Paint Cleaning extracts and emulsifies all traces of wax, oil, and grease from hard surfaces. Rinses with water . . . leaves no film. (Data Sheet # 245)

Carbon Tetrachloride Replacement . . . a methylated aromatic solvent available in open-top lever closures, 5-gallon kits including a steel dipping and drier basket. Designed for mobile unit shop, bench cleaning.

Gunk . . . this versatile base concentrate when diluted with appropriate solvents anticipates every automotive, military, and industrial grease-cleaning problem. (Data Sheet # 248) Formulae available.

Write for Catalog and Engineering Data Sheets

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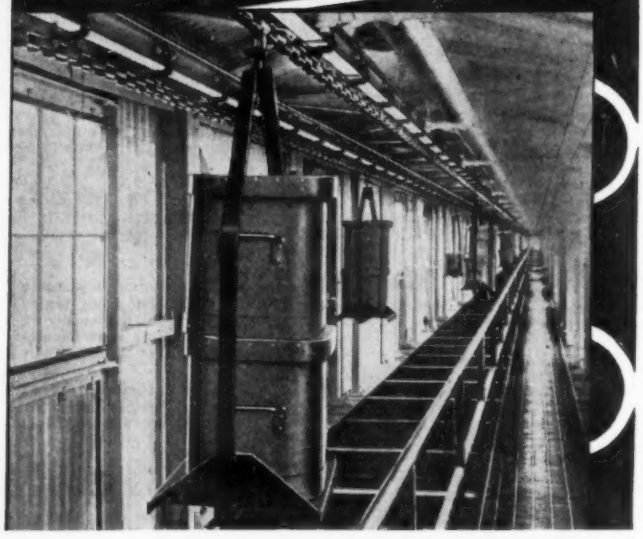
Confidential formula bulletins will be made available whenever the particular purpose and use that the formula is to serve is described.

How to Handle Ordnance Materiel EFFICIENTLY!



THIS ALVEY-FERGUSON Engineered Trolley Conveyor with pendant-type carrier hauls filled containers from remote parts of the building—at the most practical handling speeds—and at uniform safely-spaced distances between containers, then returns empties to subsequent fillings.

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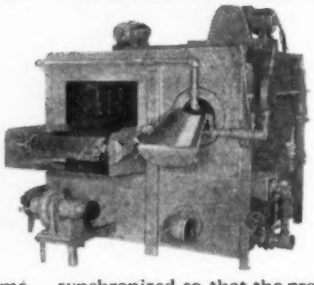

This A-F Duo-Cleaning Equipment was built in the form of a "Siamese Twin"—with the Rotary Drum and Wire Mesh Conveyor Machines built side-by-side in the same housing and using the same set of pumps and the same supply tank.

Small parts are conveyed to this equipment in boxes covered with cutting oil. The parts and boxes are thoro-cleaned as they "race through" different sides of the equipment—which is synchronized so that the proper box always comes out first, in plenty of time to carry the same parts on to their destination . . . Have YOU a products handling or a metal products cleaning and finishing problem? We can help you. Write today.

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Professional Digest

Air Gaging of Guns and Ammunition

THE Ordnance Department continually strives for improvement in gaging methods. The objective of gage developments in the Department during this war has been to insure interchangeability in manufacturing to a high degree in order to meet the requirements for extremely large rates of production of ordnance matériel. This has been achieved by closer dimensional control and faster means of inspection. Comparatively recent developments and refinements in the science of gaging have been paramount in the attainment of this end. There are many different types of gages in use today—some simple, others complex. However, the particular type or design of a gage or gaging device to be used to meet a given set of conditions will be found if only one purpose is kept in mind; that is, to determine that the specified dimensions of a component part have been complied with and that the part will function when assembled with other mating parts.

In the search for a higher degree of perfection in dimensional control and a more rapid means of inspection, the air gage has been found to be a highly effective tool in the solution of many unusual gaging problems. Air gaging may be defined as the utilization of the flow of air to provide the magnification necessary to detect variations in dimensions. The chief advantages of air gaging are sensitivity, speed of inspection, and long gaging life. An added advantage is that no unusual accuracy need be built into the gage. The action involved in air gaging is similar to that of air flowing through a pipe and escaping from a nozzle. For if the finger were gradually made to approach the end of the nozzle from which the air is escaping and a pressure gauge were mounted in the pipe before the nozzle, the pressure gauge would gradually indicate a pressure equal to the static pressure from which the source of air is being supplied.

In measuring internal diameters by means of air gaging, a straight ground and lapped plug is utilized. A nozzle or nozzles are drilled in the plug so as to allow a flow of air between the plug and the diameter to be checked. Variation in the size of diameter being measured results in varying pressures being indicated on the means used for determining the size variation. In checking outside diameters, the same principle is used. However, instead of a plug, the air is introduced through a ring. The flow of air between the gage and the component part is an important factor, and, for this reason, a groove or grooves are placed in close proximity to the orifices to allow an unrestricted flow of air. Accuracy in keeping components within limits at all times is determined by reference to master plugs or rings.

Two general types of air gages are now used. The back-pressure type, described above, operates on the principle of varying the air pressure. The second type, the velocity type, operates on the principle of varying the air velocity at constant pressure. Both types have certain advantages, and the usage will be dictated by the conditions imposed.

Considerable development in air gaging had been accomplished in this country before the start of the 1940 production emergency. Reference to the U. S. Patent Office records shows that a patent for an air gage was issued to Harrington as early as 1922. A great deal of development had gone on in air gaging in France, and these devices are described under several U. S. patents granted to Mennesson. In this country, air gaging had been used in the automotive industry for the inspection of Diesel fuel-pump cylinders, carburetor jets, connecting-rod bearings, and numerous other internal-gaging functions.

After the beginning of the 1940 production emergency, tremendous increases in the production of small- and medium-

caliber guns brought about an urgent need for the streamlining of gaging technique. Although before this time several different types of gages had been used for the inspection of guns, these gages were not conducive to rapid inspection and could only be used by highly experienced inspectors. Further development of the air gage was initiated by the Ordnance Department at that time. Since then, the air gage has proved to be a contributing factor in the streamlining of gaging procedure and has been adapted to many different types of ordnance material. It has made speedier inspection possible.

IN the gaging of gun barrels and chambers, the air gage has many advantages over other types of gages used for similar functions. For, in addition to checking internal diameters, it can check taper, bell-mouth, and out-of-round conditions. The air gage is used for checking the gun barrel before rifling and the rifling grooves of the finished gun barrel. In checking caliber .50 gun barrels by the use of an air gage the inspector passes the gaging head, which is attached to a long flexible rod, through the bore. The flexibility of the rod eliminates any error in misalignment of the gaging head, since it allows it to center itself as it is passed through the bore. As the rod is passed through the bore the inspector watches the indicator. The indicator will change its position if there is any variation in the diameter of the bore.

In order to check for an out-of-round condition, the inspector

AIR GAGE FOR CHECKING CARTRIDGE CHAMBER OF 40-MM. GUN BARREL

will rotate the rod, noting any variation in the indicator. If the indicator remains within tolerance, the barrel is acceptable. An undersize or oversize condition at any point will be shown by the indicator. After the gun bore has been rifled, a gaging head made to the dimensions after rifling will be used to check the diameter of the rifling grooves using the same procedure. As already stated, the air gage is used to check gun cartridge chambers.

Illustrated above is a type of spindle for inspection of the 40-mm. tapered cartridge chamber. The spindle has a number of pairs of diametrically opposed orifices for checking points on the tapered sections and on the barrel end of the chamber. Inside the spindle an adjustable plunger-type valve directs the air stream through one pair of orifices at a time, making it possible to inspect any of the predetermined points at will, without regard to sequence. The tolerance markers on the indicators are set to the maximum and minimum master chambers shown. In inspecting the gun chamber, the spindle is inserted in the chamber and the air directed to one pair of orifices at a time. If the indicator remains within the tolerance limits for all sets of orifices the chamber is acceptable.

Another interesting and unusual application of air gaging is the checking of the thickness of primer strip. As this strip is the basic material for the manufacture of cups for primers and

"Vive l'Americains!"

Thus shouted the joyful people of liberated French towns as they threw flowers and kisses at the crews of M-7 tank destroyers. They might also have shouted "Vive le Fitzgibbons!" if they had known that many of those same Tiger-killers were built by the men and women in the Fitzgibbons shops.

Those tank destroyers have answered the much-vaunted Nazi Tiger tank with a louder snarl and a deadlier pounce. And one bite of their 105 mm. gun can convert the Tiger into scrap.

We consider our work on the M-7 one of the brightest stars in a record of 58 years of success in fabricating steel. Much of the production engineering behind these tank-smashers is the fruit of our many years of building steel boilers. Much of what we have learned in building tank destroyers will aid us in making even better Fitzgibbons steel boilers as America needs them.

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cartridge cases, it is imperative that the strip be of proper thickness at the start in order that the final dimensions after successive operations be met. Prior to the use of the air gage, ball micrometers and various types of dial-indicating gages were used to check this strip, but all methods proved to be slow in operation. In addition, they were highly inaccurate, for readings could not be duplicated either by the same inspector or other inspectors.

Primer strip is now checked with rapidity and accuracy with the air gage. Tolerance limits are set up on the indicator by reference to maximum and minimum master-setting blocks. Duplication of indicator readings is obtained by the use of this instrument, and no special skill is required in order to gage the strip. It is well to point out why this application is unusual, for this particular type of strip must be held to a tolerance on thickness of plus or minus 0.0005 inches. In addition, the edgewise and lengthwise curvature is of such a degree as to prevent the use of ordinary gaging devices. Also, due to the relative softness of the material, undue pressure on the ball or cone points of the micrometer or dial indicator gage would cause inaccurate readings.

Drilling Holes with the M4 Medium Tank

Capt. J. E. Heath, U.S.M.C.R.

SHORTLY after the capture of the Cape Gloucester Airdrome in January of this year, serious problems confronted a Naval Construction Battalion. This is an account of the particular phase, and its solution, of supplying a huge amount of surfacing material to put a highway and strip into operation when gravel and sand had failed.

On the shore of Borgen Bay, about nine miles from the strip, was a mound of volcanic ash. Once dug out, this made excellent surfacing material, and work was started at once to get a pit into operation. After scraping away the outer clay surface of this 125-foot mound, Composition "C" was used to blast it out. Power shovels loaded it into trucks.

The first method of blasting was unsatisfactory because it would not produce the slag in sufficient quantities. This method consisted of drilling holes 1½ inches in diameter and 8 feet deep, using a compressed-air drill. These holes were cleaned out and loaded with Composition "C", about ten pounds maximum per hole. Several of these charges were exploded simultaneously, thus producing a few truckloads of slag. The shovels would then chew away at the mound until the long process was repeated. Eight to ten hours were spent preparing each blast. Long lines of trucks waited; hundred of tons of equipment waited for the road; planes waited to be moved in.

In search for a faster method of drilling holes, a Seabee discussed the problem with a Marine tankman—whose unit was bivouacked near by. At the end of the discussion, an M4A1 Sherman tank pulled across the road and proved to be the solution. Its M3 75-mm. gun put three shovels to work twenty-four hours a day. Each morning the tank would cross the road, fire fifteen to twenty rounds into the mound and then withdraw to clean the gun, its day's work finished. The Seabees would clean out the holes, load them, and explode them before noon, bringing down hundreds of cubic yards of slag. This would keep the shovels busy until the next day. The speed-up was enormous; the saving in man-hours and money amazing.

When using the compressed-air drill the holes had to be drilled at the base of the mound. This gave a tunneling effect as the project progressed. The tank could fire projectiles at any angle or height the Seabees wanted them.

The Seabees continued to use compressed air to drill holes down from the top of the mound. The tank could have been

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moved up on the mound from the rear and set in a position to fire minus 45 degrees holes, but there was no way to clean out holes to the depth needed, and top blasting was used only to remove the clay cap of the mound.

SEVERAL types of ammunition were tried in the M3 tank gun. Of interest to Ordnance personnel will be the figures that were checked and averaged. Shell, fixed, AP, M61, Super (2,030 f.s.), proved to be the best. It would punch a hole about eight inches in diameter and from ten to sixteen feet deep. In one case it penetrated nineteen feet. Sometimes the projectile would be deflected as it went in, but altogether it was a very satisfactory process. When cleaned out, this hole could be charged with a hundred or more pounds of explosive. On one occasion fifteen such holes were charged with 3,000 pounds and could have been loaded to 2 tons but for the damage that might have been caused in the adjacent areas. This procedure was certainly a far cry from the previous method of blasting.

Shot, fixed, SAP, M72, Super (2,030 f.s.), made a hole a little larger in diameter than the M61 but only about half as deep. The inside cavity was larger, indicating that the shot may have had a tendency to tumble. This shot was used only when there was a shortage of the M61, although in itself it was satisfactory to a certain extent.

Projectile, APC, M61, Super (2,030 f.s.), with Explosive "D" filler, was tried, hoping to speed up the operation by its blast effect. It was not satisfactory. Its penetration ran from three to five feet. The cavity was large, but not deep enough and was difficult to clean out and load.

Shell, fixed, HE, M48, Super (1,980 f.s.), with fuze, PD, M48, was used to knock down overhanging ledges which were endangering the shovels. Set on "superquick" it was practically useless for the purpose for which it was wanted. Only a few shots at this setting were fired. Set on "delay" it worked well on the loose stuff, but since each shot would knock down but a cubic foot or so of the solid slag its use was limited. In order to enlarge the cavity of the AP hole an HE shell was fired into it. Set on "delay" it did enlarge the cavity but made it difficult to clean out and charge and therefore was slower than straight AP holes.

Due to the location of the mound, the firing was done at about fifty yards. It is believed that maximum penetration was not obtained due to this short range. The slag was easy to handle once it had been blasted, but solid enough to allow the shovels only to chew at it until it was blasted.

When the tanks were moved from the area for tactical reasons, a half-track M3, mounting the M1897A4 75-mm. gun was moved in to do the firing. The results of its firing were nearly as satisfactory as those of the tank. The tank had one advantage —that of saving a little time. It could pull along the face of the mound, with the turret rotated, and fire at the markers set up. The half-track, due to its limited traverse, had to change position after each shot or two. Firing fifteen or twenty shots took about a half hour more with the half-track. Artillery could be used to obtain the same results as a tank, but the tank is a real timesaver.

RECONDITIONING DEFECTIVE ARTILLERY AMMUNITION

ARTILLERY ammunition reconditioning, a newly inaugurated service at Fort Sill, Okla., is saving the Army thousands of dollars and helping to alleviate high cost and dangerous shipping problems in the transportation of explosives. The program is under the supervision of Lieut. Col. Roy L. Butler, post Ordnance officer at Fort Sill.

Field-artillery projectiles and other ammunition found to be defective before or after issue at the post are now sent to the reconditioning section for repair or replacement of parts instead

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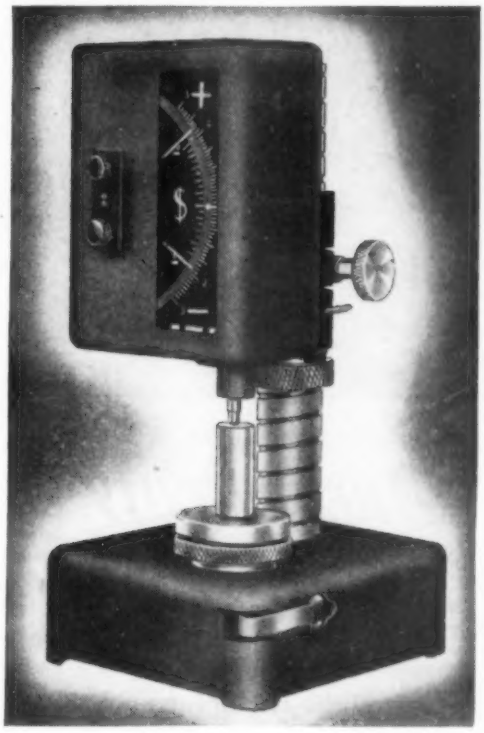

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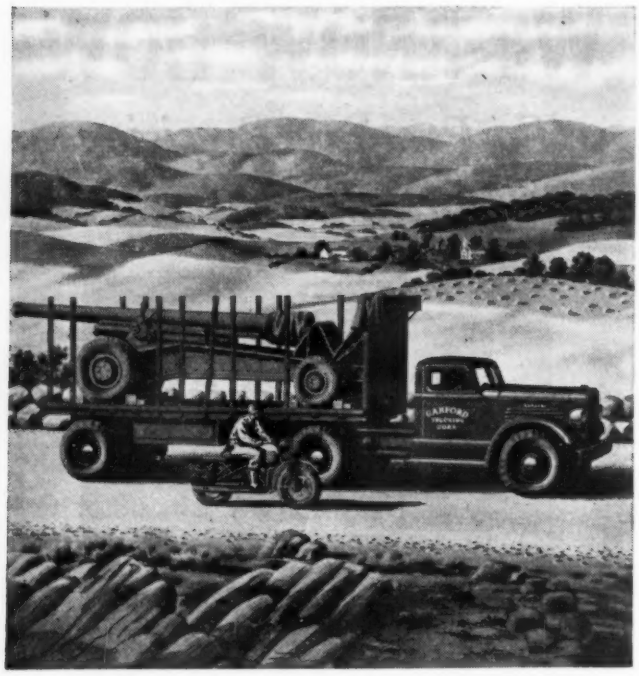

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of being returned to arsenals. Cartridge cases at times may become dented or flared, fuzes become loose, or rotating bands may be bent, either in shipment or handling in the field. Shells with such defects are marked and sent to the ammunition repair section. Here projectiles are separated from cases and all dents and flaws in the propelling-charge casings removed by inserting over a special anvil and pounding with rawhide or wooden mallets. Propelling-charge powder bags are replaced whenever necessary, and, in the event of misfired shells and like malfunctions, the entire case is replaced.

Time fuzes are checked for serviceability, tightened when loose, or replaced entirely when not safe for use by troops. Burred rotating bands are filed and smoothed, and other parts of the projectile proper are checked for serviceable condition.

After the repairing of defective parts the shells are assembled, crimped, inserted in undersize breech bore gages to test them for sure fit in field guns, thoroughly rechecked, and then tagged by Ordnance workers as serviceable ammunition to be eventually reissued to firing batteries at Fort Sill.

Capt. Roy E. Coleman, post ammunition officer in charge of the new shell-repair section, points out that heretofore all defective ammunition was reshipped to arsenals where it was repaired or disposed of. Today the Fort Sill Ordnance section accomplishes this work on the post, thus saving vitally needed shipping space, much rehandling, and high transportation costs.

Flak Suits Prove Their Value in Combat

FLAK suits now supplied as standard equipment for American airmen overseas have greatly reduced the incidence of serious injury among combat crews and in the opinion of fliers and flight surgeons alike are saving many lives.

As a result of early experience with this type of armor, designed to protect vital areas of the body against the hail of lead and steel encountered in aërial combat, additional protection is being devised in the form of flak shawls, blankets, and curtains now in process of development. Research and experiments in this field are being carried on by the AAF Matériel Command at Wright Field, Dayton, Ohio; the Proving Ground Command at Eglin Field, Fla.; the Tactical Center at Orlando, Fla.; and by the Army Ordnance Department at Aberdeen Proving Ground, Md., and elsewhere.

All such studies and experiments have as their objective increased protection for fighter and bomber crews with a concomitant lessening of restrictions imposed on their physical movements by bulkier and heavier armor. Although the flak suit now being produced is the fourth model to be developed since Brig. Gen. Malcolm C. Grow, Surgeon of the U. S. Strategic Air Forces in Europe, introduced the innovation while serving as surgeon of the Eighth Air Force, it is being improved constantly.

More than 400,000 flak suits have been made in the United States and shipped overseas since last fall. Many others have been made in Great Britain to American specifications.

General Grow reported that an analysis of the experience of 133 airmen struck by flak or enemy missiles of other sorts while wearing body armor showed that two-thirds escaped injury of any kind and that 10.5 per cent were killed or seriously wounded. The study yielded the following breakdown: No injuries, 65.5 per cent; slightly wounded, 24 per cent; seriously hurt, 2.3 per cent; killed, 8.2 per cent. An accompanying study of injuries received by members of crews who had not worn flak suits disclosed a substantially higher percentage of serious wounds.

Early resistance on the part of some individuals to the use of body armor, usually based on its weight and bulk and the discomfort or inconvenience of wearing it, is disappearing with the

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accumulation of experience testifying to its value. Fliers are now thinking of ways to improve and simplify it rather than of excuses to discard it. The flak suit was devised to minimize injury from spent bullets and low-velocity shell fragments originally responsible for eighty-five per cent of all casualties in air combat. General Grow and his collaborators have attempted from the beginning to provide protection particularly against head, neck, chest, and abdominal wounds.

Statements made by crew members to flight surgeons give the best evidence of the conversion of airmen to the use of the protection now provided. One waist gunner said:

"On my twenty-fifth mission I was hit by two large pieces of flak directly over the heart. The flak was deflected, although the force of the blow knocked me backward into the left waist gun position and knocked me down as well. I received no injuries except mild bruises of the chest. Two plates of the flak suit were bent considerably by the blow and one later fell out and was lost. I advise every one to wear flak suits." The flight surgeon who examined this man said he was saved a severe chest wound and probable death by his flak suit.

A tail gunner stated: "I'd hate like hell to go without a flak suit. I was flying my regular tail-gun position when I was hit. . . A 13.9-mm. (machine-gun) bullet pierced two struts and the oxygen bottle straight above me. Coming down on a vertical plane, it penetrated my flak suit and went through the soft tissues above the bone of my right shoulder. If it weren't for the flak suit the bullet most likely would have continued straight on through my lung."

Nonmetallic Land Mines

ARMY Ordnance is supplying tens of thousands of nonmetallic high-explosive land mines to General Eisenhower's liberation armies in Europe. Contrary to popular belief that land mines are a purely defensive weapon, the American armies in their advances across France and the Low Countries used mines as an offensive weapon. As our armored forces probed deeply into enemy-held territory, land mines were sown thickly along the flanks of the advancing troops to protect the spearheads against sudden encirclement by enemy troops. As our forces advanced and widened the spearheads, the mines were recovered for re-use.

Large numbers of ceramic mines are being produced from noncritical materials. Glass is likewise being used for this purpose. The Ordnance Department is also producing a light "tin-can" mine that can be carried in a soldier's pocket or pack. It may be used as a demolition charge against pillboxes, hurled as a grenade, or used as a land mine against enemy combat vehicles, thus giving the foot soldier firepower of great flexibility.

Bazooka Barrels of Paper Plastics

THE barrels of some of the flying bazookas which the Army Air Forces have installed on the Thunderbolt (see p. 467) and other types of fighter planes, are being made from a special paper plastic developed by General Electric and the Byron Weston Company. Plastic was used because it is lighter than other types of material and better adapted for this job. The resins used are fire-resistant to withstand the fiery blast of the rocket missile when launched.

Firing of the flying bazookas is controlled by the pilot in the same manner as he fires his caliber .50 wing machine guns—by pressing a trigger set in the stick. The bazookas, or air-borne rocket launchers as they are called officially, are mounted under each wing, three in a cluster. The weight of the rocket installation is approximately 450 pounds, and the walls of the barrels are about one-fourth of an inch thick. All six of the barrels may be fired at the same time, or they may be fired individually. The rocket projectiles also may be used as bombs.

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Office of War Information photograph

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Installs directly into the air line. Injects exactly enough oil into the air stream to create an oil-air fog, lubricating every working part.

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Automotive Maintenance

Rebuilding Army Motors by Mass-Production Methods

FROM the battle zones, from maneuvers, from "line" duty at home, unending streams of motors from trucks and half-tracks converge on the Army Ordnance base shops of the Ninth Service Command, one of which is located at Los Angeles. These motorized workhorses of the Army have seen service such as civilian vehicles seldom encounter. Days of rough riding over rocky roads—or no roads at all; days of exposure to mud, sand, and sea water have taken their toll. However bad the state of incoming trucks and half-tracks, few are considered to be beyond rehabilitation.

Interchangeability of parts, reclamation of old parts, plus advanced methods of handling, have made possible the adoption of a mass-production technique of overhaul which continuously converts unserviceable automotive equipment at one end of the assembly line into revitalized, serviceable units at the other end.

Reclamation of more than seventy per cent of all engine parts and their re-use in rebuilt motors have been accomplished through the employment of new, scientific engine-rebuilding methods. Less than thirty per cent of all parts, including pistons, rods, and major assemblies are found to be beyond reclamation. In spite of the fact that every possible old part is reclaimed and re-used, motors are assembled at rates of speed which compare favorably with production rates for the building of new motors.

The large-scale redemption of used Army automotive equipment was made feasible, both in time and in cost, by the adoption of methods which permitted mass-production handling. It is clear, for example, that if each of the hundreds of units which make up a motor had to be individually cleaned by hand, it would be cheaper to replace the motor than to attempt to rebuild it. Effective methods of large-volume cleaning had to be worked out before the mass-production system of overhaul became feasible. The lack of such methods presented a production bottleneck which resulted in increased costs and delayed the return of vitally needed automotive equipment to the Army's combat and service activities.

The difficulty of evolving adequate cleaning methods can be better appreciated when the following factors are considered. Since Army vehicles are frequently operated under maximum loads and speeds, moving parts tend to be heavily caked with carbon, tenaciously adherent deposits of which are frequently found on pistons, valve seats, cylinder walls, and other areas affected by the combustion of gasoline. Crankcase surfaces are usually coated with baked-on "engine varnish." Equipment returned from overseas has often been affected by the action of salt water and is more or less heavily corroded, rusted, and scaled. To these conditions may be added the normal complement of grease, dirt, mud, clay, and road film which tends to coat any piece of automotive equipment in active service.

The thorough removal of all these deposits is essential to proper rebuilding. The inspection of cleaned parts frequently reveals cracks, flaws, and distortions of the metal which could not have been discovered in any other way. All necessary resurfacing, reboring, and realignment work obviously demands an initially clean surface, and a clean surface is a prime requisite for durable paint adhesion. Operational testing of repaired units would have little significance without the assurance that all working parts are thoroughly clean and mechanically sound.

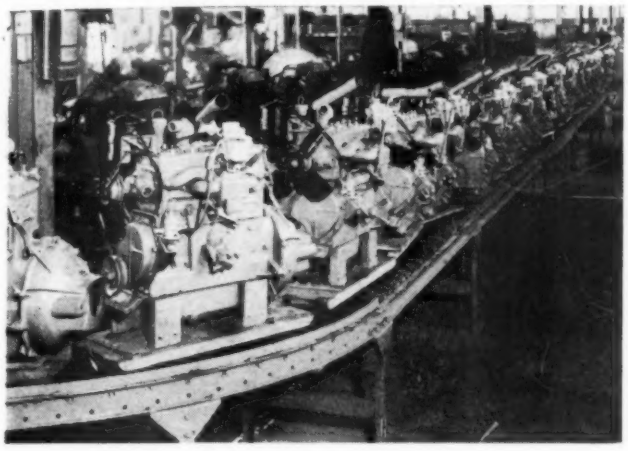
THE success of the measures adopted can be evaluated from the fact that, at the Ninth Service Command repair shops at Los Angeles, production rates were stepped up, after scientific cleaning procedures were adopted, to the point where 1,000 to 1,500 completely rebuilt motors are returned to service every

month. Under the old hand methods of cleaning, it required from four to twelve hours to clean a cylinder block. This job is now being done in forty minutes, on a regular production schedule.

Mass-production rebuilding, as carried on at the repair shops, consists essentially of four operations. The first is disassembly. Work is scheduled so that only equipment of a given type is placed in production during a particular run. There is no need for identifying particular units since all are interchangeable, except bell housings, crankshafts, and camshafts. In this article we are utilizing the method of overhauling the engine and its accessories as illustrative of the overhaul process in general.

THE first operation is the removal from the engine of the carburetor and fuel pump and of the electrical equipment, including generator, starter, voltage regulator, and spark plugs. These units are routed to a separate department for processing. The engine is then steam vapor cleaned externally. The removal of heavy grease and dirt prior to disassembly gives the mechanic easy access to the work, prevents pollution of the chemical cleaning solutions used later, and speeds the removal of carbon and rust in the cleaning baths.

Disassembly of the engine then proceeds. All similar parts



REBUILT ENGINES READY FOR SHIPMENT

such as pistons, crankshafts, connecting rods, and valves are sorted out and placed in convenient wire baskets. Some internal engine parts will still be heavily greased, not having been reached during the initial steam vapor cleaning, and a steam vapor flush is used to remove this loosely adherent soil. Exterior units, such as manifolds, may be substantially clean, except for the presence of a rust film. Camshafts, connecting rods, valves, and valve springs are usually coated with light oil and carbon deposits. Other units may be affected by both carbon and rust. Units are routed on conveyor rollers to specialized cleaning baths in accordance with the type of treatment they require. A dip in one part of Mulsine to ten parts solvent removes excess grease and oil, and tends to soften carbon. Parts are then soaked in Fuzee (which penetrates and loosens carbon and removes paint) for a half hour. The bond between soil and metal having been broken, these deposits are then easily rinsed away in a 5-minute dip in hot "Type X" solution. A cold-water rinse completes this process. Rust is removed in a solution of "W. O. #1," which material also removes light grease films and phosphatizes and passivates the surface, preparing it for painting.

The advantages of the specialized cleaning methods outlined above are numerous. Hand-buffing, hand-scraping, and time-consuming manual cleaning operations are eliminated. The time that skilled mechanics formerly devoted to removing grease and carbon is now employed in operations requiring mechanical skill, while all cleaning work is handled on a productive basis by unskilled men and women workers. Centralization of cleaning operations eliminates duplication of work in different depart-

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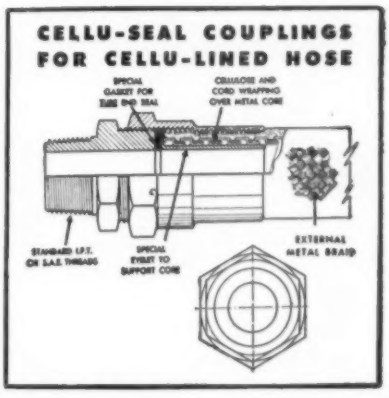

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Automotive Maintenance

ments and makes possible an economical floor plan wherein all parts can be cleaned immediately following disassembly.

The overhaul of accessories follows the same general plan as that employed in processing the major units. Formerly, fifty per cent of all rebuilt carburetor assemblies were rejected by inspection and returned for reprocessing. Responsible for this high rate of rejections was the difficulty encountered in thoroughly cleaning these accessories, made largely of zinc-alloy die casts. The tarnish which coated these castings after a period of service was sufficiently heavy to conceal serious cracks and defects which may have developed during use. Further, even minute accumulations in bleeds, jets, and nozzles were sufficient to impair the efficiency of the equipment. The use of a brightening process called "Zinctone," which removes tarnish and corrosion, seals the pores of the die-cast surface, restores the original luster of the metal, and protects against further corrosion, cut down the rate of rejections by inspection from over fifty per cent to less than one per cent.

The third major overhaul operation involves the inspection of all units and the making of necessary repairs and replacements. Since the use of advanced cleaning methods results in a definite hourly rate of production, the repair and replacement activities are fed continuously from the output of the cleaning rooms. The fourth operation is reassembly. The reassembled units are each subjected to an operational check and test run which assures that the equipment is ready to be placed in service. Crating for shipment is the last step in the process of reclaiming automotive equipment.

Because of the shortage of male help, the entire plant setup was arranged to make possible the employment of a maximum number of women workers. Numerous jigs and special devices were developed which make for more convenient handling of parts and which simplify mechanical operations.

Timing the Retread

REPORTS from the field indicate that at present many of the Army tires which are sent in to the tire-collection centers for new treads are removed from service *too soon*. A tire can, and should, be used as long as the tread is still raised slightly in the center. Any tires in this category sent in to the tire-collection centers must be returned to the field and reinstalled. The handling necessary for sending them in, inspecting and classifying them, and returning them to service therefore becomes wasted motion and effort and puts an unnecessary strain on the already overburdened collection centers. Only when the treads wear smooth in the center are tires ready for a "face-lifting" job.

The number of tires which are removed from vehicles too late—when the rubber has worn down to the cord body of the tires—also represents a serious condition, since the scarcity of tire carcasses is a more important factor in the present task of supplying tires than the scarcity of rubber for new treads. This is due not only to the shortage of manpower, but also to the fact that synthetic rubber is far less satisfactory for use in construction of heavy truck tire casings than it is for use in new treads. Therefore, it is extremely important that casings, many of which still contain natural rubber, be preserved to the maximum degree. Responsible personnel must become increasingly conscious of this condition and take the necessary steps to overcome it. The practice of rotating tires to different wheel positions when treads cup, or wear irregularly, must be followed. Irregular wear on front tires may be due to improper wheel alignment—this should be checked and corrected. As in almost every military situation, success depends to a large extent on acting at the right time. Inspections must be regular and thorough. *When cuts expose tire cords, tires must be removed immediately and sent in for reconditioning.*

Book Reviews

EXPLOSIONS—THEIR ANATOMY AND DESTRUCTIVENESS. By Clark Shove Robinson. New York: McGraw-Hill Book Company. 88 pp. 25 charts. $1.50.

THIS little volume has attained that rare category of being a "must" for all military or civilian personnel whose duties require of them technical or administrative responsibilities in connection with the storage or handling of large quantities of explosives or ammunition.

In the past, a few reports on individual explosions or groups of explosions have been published. In none of these, however, was any attempt made to compile and publish the data in such form that they could be used easily by the man in the field nor was any attempt made to make a complete mathematical analysis. This has been remarkably well done in Colonel Robinson's book. Where the charts necessarily allow a large degree of variation because of the somewhat eccentric action of various explosions, Colonel Robinson has been able to deduce graphs enabling prediction in advance of the effects of an explosion with a sufficient degree of accuracy to be useful.

Among the remarkable charts that form one of the most useful portions of the book are those showing crater size, "intraplant" safe distance, the average limit of serious structural damage, the limit of earthwave damage, the limit of inhabited-building distance, the minor structural-damage limit, the missile limit, and the broken-glass limit, plotted against various weights of explosives involved.

Another remarkable conclusion the author presents is the similarity in behavior of all explosives of given classes, and he has found that physical factors, such as density, reconcile some of the variant results previously thought to be due to the chemical characteristics of the materials. The favorable reception of this book by officers known to this reviewer, both here and abroad, is indicative of its interest and value.

BOMBERS ACROSS. By Capt. Edgar J. Wynn. New York: E. P. Dutton & Company. 178 pp. $2.50.

WITH a dedication to "Jane and to the wives and sweethearts of all airmen" together with a photograph of Jane herself, the author sets a new style, and a pleasing one, in book format. Lowell Thomas provides the introduction, but even this fades in comparison with the amazing story of the author's experiences and those of his comrades with the Air Transport Command in flying the Atlantic, the Arabian Desert, Iran, Iraq, and the other corners of the earth where transport commands operate. These men fly the "heavy stuff," and their flying is very different from combat work. The story is exciting and something new in wartime adventure.

THEY WERE THERE. Edited by Curt Riess. New York: G. P. Putnam's Sons. 670 pp. $5.

HERE is an anthology of World War II. The editor has compiled, from the writings of over 125 correspondents, the story of this war as it was seen on the spot and at the time. He has divided the book into eleven periods dating from 1922. In his introduction he gives an insight into the make-up of the writers themselves, their various specialties, and the power which actuates this fine guild of craftsmen.

The book is well balanced, and the articles are arranged in sequence with connecting "headlines" where necessary. Often the reader forgets that the book was not written by one man. For the average reader Part VIII—"United States at War,"

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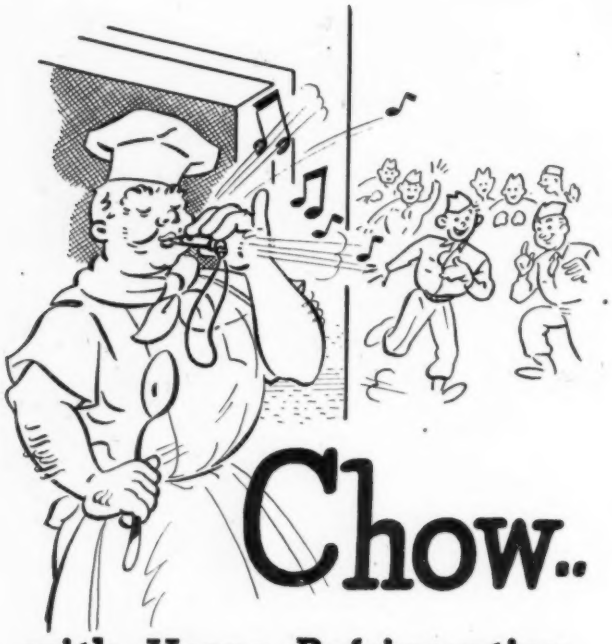

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Book Reviews

starting with Pearl Harbor; Part IX—"Africa"; Part X—"Italy"; and Part XI—"Global War", will attract first attention.

This book is an invaluable record, one to be kept and assuredly one to be referred to often. It is history, not of the past but of the present, put up in a delightful capsule. A novel addition comes in the form of a biographical sketch of each contributor, alphabetically arranged with references to his part in the book. Acknowledgments and an index of sources complete this interesting and valuable work.

OUR ENEMY JAPAN. By Wilfrid Fleisher. Washington: *Infantry Journal*. 179 pp. $0.25.

THIS is the story of the relations of the United States and Japan from the time Commodore Perry opened up the island empire to foreign intercourse down to Pearl Harbor. In presenting the military, political, and racial struggle, the author, as a newspaper correspondent, is fully equipped to give the facts about our most ruthless enemy.

The author has presented the sort of people we are fighting, their many years of planning to conquer Asia, the strength of Japan's army and navy, and her economic position—the weakest link in her armor. The reader will find in this book many interesting sidelights and much factual information about the Mikado and his futile war lords.

WEST POINT. By E. D. J. Waugh. New York: The Macmillan Company. 246 pp. $2.50.

MRS. WAUGH has made a fine contribution to military literature. Unfortunately she died before the book was published but not before she had corrected the proofs. It is regretted that she will not know the acclaim with which this book is sure to be received, particularly by graduates of the Military Academy.

She tells of the academy from its humble beginning and precarious early life through the political machinations that constantly hampered the administration of the school to the fine foundations laid by the father of West Point, Col. Sylvanus Thayer, to whom the Nation owes everything that has come out of the Military Academy since its beginning.

We follow its progress quickly to the present war with excellent word pictures of the leaders of the armies, intimately told, and containing personal references unknown before.

MODERN RECONNAISSANCE. Harrisburg: The Military Service Publishing Company. 230 pp. $1.50.

THIS is a collection of reprints of articles on reconnaissance which have appeared in the *Cavalry Journal*. They are written by distinguished army officers of all nations and the compiler has selected and arranged them in an excellent manner. The old axioms and the new conditions and procedures are all carefully explained and illustrated. An excellent compendium of instruction on the subject.

DAYBREAK FOR OUR CARRIER. By Lieut. Max Miller, U.S.N.R. New York: Whittlesey House. 184 pp. $2.50.

THE foreword by Rear Adm. Arthur C. Davis, U.S.N., tells that the book "symbolizes the heartening crescendo of our aircraft-carrier power and effectiveness in the war in the Pacific." The clarity of the prose and the effectiveness of the pictures provided by Lieut. Charles E. Kerlee places the reader aboard the carrier, thinking the thoughts and gaining the impressions of those men who go down to the sea on the flattops. The ship is the leading character in the story from the beginning where it is described as "a piece of the United States" to the end where it has passed through D-day and all pilots have returned.

The story covers the cruise from the West Coast over the

Book Reviews

Pacific, with constant practice of "general quarters," the detailed descriptions of the little-known occupations aboard the carrier, the people who perform their duties without glamour and fanfare, those who remain below decks at all times, the "airdales" who make up the ground crews aboard ship, and the speed and timing of every movement.

Admiration for the most important carrier man, a pilot who is selected to be "landing signal officer," comes when his duties and skill are enumerated. All these elements fit together and make a story that lives. The author may be remembered for his book "I Cover the Waterfront," but he is superb in the present field of writing.

WAR BELOW ZERO—THE BATTLE FOR GREENLAND. By Col. Bernt Balchen, Maj. Corey Ford, and Maj. Oliver Lafarge. Boston: Houghton Mifflin Company. 127 pp. $2.

BERNT BALCHEN has spent much of his life at the frozen ends of the earth. Here he describes the difficulties encountered in the Greenland icecap and at our bases there, where he is in command of our air forces. The thrilling rescues by airplane and dog team, the trials of the long night, the hardships and cruelty of the arctic are graphically recounted. Balchen's prediction that the airways of the future will be over the pole seems very plausible after reading his book. The coauthors contribute parts covering their own fields. This is a small book, but full of real information and exciting adventure.

SOLDIERS IN THE PHILIPPINES. By Col. William T. Sexton. Washington: *Infantry Journal*. 246 pp. $0.25.

THIS book, a history of the Philippine insurrection, first published in 1939 by the Military Service Publishing Company under the title "Soldiers of the Sun," is a special edition in a pocket format. It is very instructive and good reading in view of the battles soon to be fought to liberate the Philippines.

This book is intended to close a gap in American and Philippine history and is probably one of a few which acquaints the reader with what actually happened. The problems which faced our forces while operating in the tropics produced unusual difficulties which are forcefully outlined here.

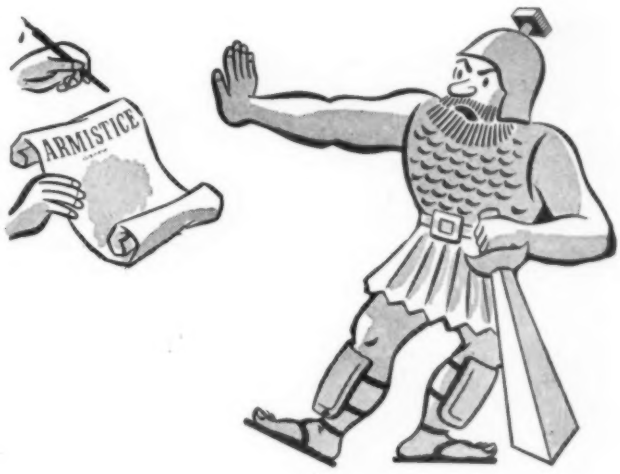
EAST BY SOUTHWEST. By Christopher La Farge. New York: Coward-McCann, Inc. 208 pp. $2.50.

THE mythical and impossible nautical course which is given in the title should not cause the reader to assume that this is a funny book. The author, as a correspondent in the Southwest Pacific, saw many things which in themselves were incomplete and not too interesting. By interlarding these facts with creative writing, he gives us a synthesis of what he saw, the people and things, what they did and said. "Fiction," he says, "cannot replace factual war reporting, nor should it attempt to do so. It should supplement it, and that supplementation is, to my view, a most necessary function that has been sadly overlooked."

Just as the vivid description by the participant of an event, when told orally, surpasses the dry factual report of the same event, so this very new type of fiction-fact reporting of the war is delightful and most convincing. Many of the stories have been published elsewhere in periodicals, but their collection here has given the reader another different and most fascinating book of the war.

THE MAKING OF MODERN CHINA. By Owen and Eleanor Lattimore. Washington: *Infantry Journal*. 178 pp. $0.25.

THIS pocket edition gives the story of China in four parts—"The Land and the People," "The Oldest Living Civilization," "Modern China," and, "Today and Tomorrow." It is a splendid



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Book Reviews

account of these remarkable peoples and is well worth reading in view of their present travail during seven years of exhaustive war.

Military Applications of Mathematics. Lieut. Paul P. Hanson, U. S. Army, Ret. New York: McGraw-Hill Book Company. 447 pp. $3.

Numerous books relating mathematics to military and naval uses have appeared and are appearing. Each, of course, has a particular field to which it is addressed. The present text covers a wide range of subjects including military maps, field artillery, seacoast artillery, the mathematics of air navigation, range finders, bomb ballistics, motor transport, antiaircraft gunnery, and practical military engineering. It closes with a "mathematics refresher" which, in ninety pages, embraces a review of what may be called high-school mathematics.

The text is excellent. It is clear, very well illustrated, and the typography is fine. Short and well-chosen references are given for those who wish to pursue the various subjects further. Numerous illustrative examples are furnished. The book deserves serious consideration from those interested in securing a general knowledge of the fields covered or in search of a textbook for use in elementary instruction in them.

Books Received

Foreign Maps. By Everett C. Olson and Agnes Whitmarsh. New York: Harper & Brothers. 237 pp. $4.

The Fight at Pearl Harbor. By Blake Clark. Washington: *Infantry Journal*. 104 pp. $0.25.

Enginology. Paterson: Wright Aëronautical Corporation.

A Guide to Naval Strategy. By Bernard Brodie. Princeton: Princeton University Press. 314 pp. $2.75.

The Wild Blue Yonder. By Emile Gauvreau. New York: E. P. Dutton & Company. 386 pp. $3.

So You're Going Overseas! By Capt. Stockbridge H. Barker. Washington: *Infantry Journal*. $0.25.

Seamless Tube Data. Pittsburgh: Seamless Tube Institute. 324 pp. $2.50.

One Man's War. By Sgt. Charles E. Kelly. New York: Alfred A. Knopf, Inc. 182 pp. $2.

Freedom Speaks. By George F. Reynolds and Donald F. Connors. Washington: *Infantry Journal*. 245 pp. $0.25.

French Dictionary. By Frank Henius. Washington: *Infantry Journal*. 199 pp. $0.50.

Spanish Dictionary. By Frank Henius. Washington: *Infantry Journal*. 252 pp. $0.50.

Infantry Attacks. By General Field Marshal Erwin Rommel. Washington: *Infantry Journal*. 265 pp. $3.

Defense against Chemical War. Washington: *Infantry Journal*. 90 pp. $0.25.

Insignia and Decorations of the U. S. Armed Forces. By Gilbert Grosvenor. Washington: National Geographic Magazine. 97 pp.

Author's Choice. By MacKinlay Kantor. New York: Coward-McCann, Inc. 497 pp. $3.50.

Military Law for the Company Commander. By Julian J. Appleton. Washington: National Law Book Library. 141 pp. $2.50.

Mechanical Springs. By A. M. Wahl. Cleveland: Penton Publishing Company. 435 pp.

The Pacific World. Edited by Fairfield Osborn. Washington: *Infantry Journal*. 156 pp. $0.50.

We Cannot Escape History. By John T. Whitaker. Washington: *Infantry Journal*. 345 pp. $0.25.

Rifles and Machine Guns of the World's Armies. By Capt. Melvin M. Johnson, Jr. Washington: *Infantry Journal*. 406 pp. $0.25.